

NewScientist

December 20, 2014 - January 2, 2015

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OF THE
YEAR

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Skiing on Venus / The eight legs of Christmas / Chocolate's inner life
Shall I compare thee to a line of code? / Why the ultimate answer is... 37*



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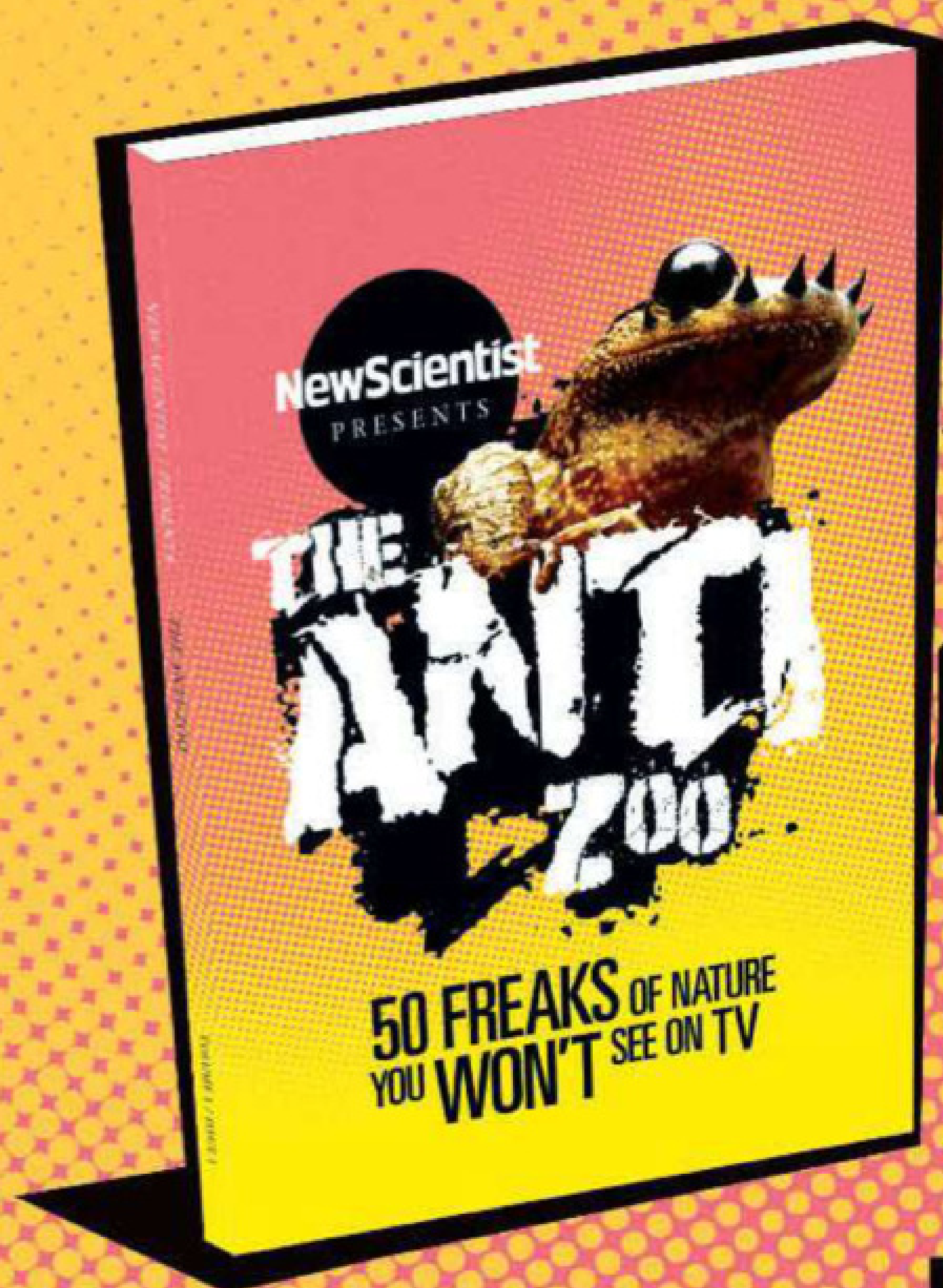
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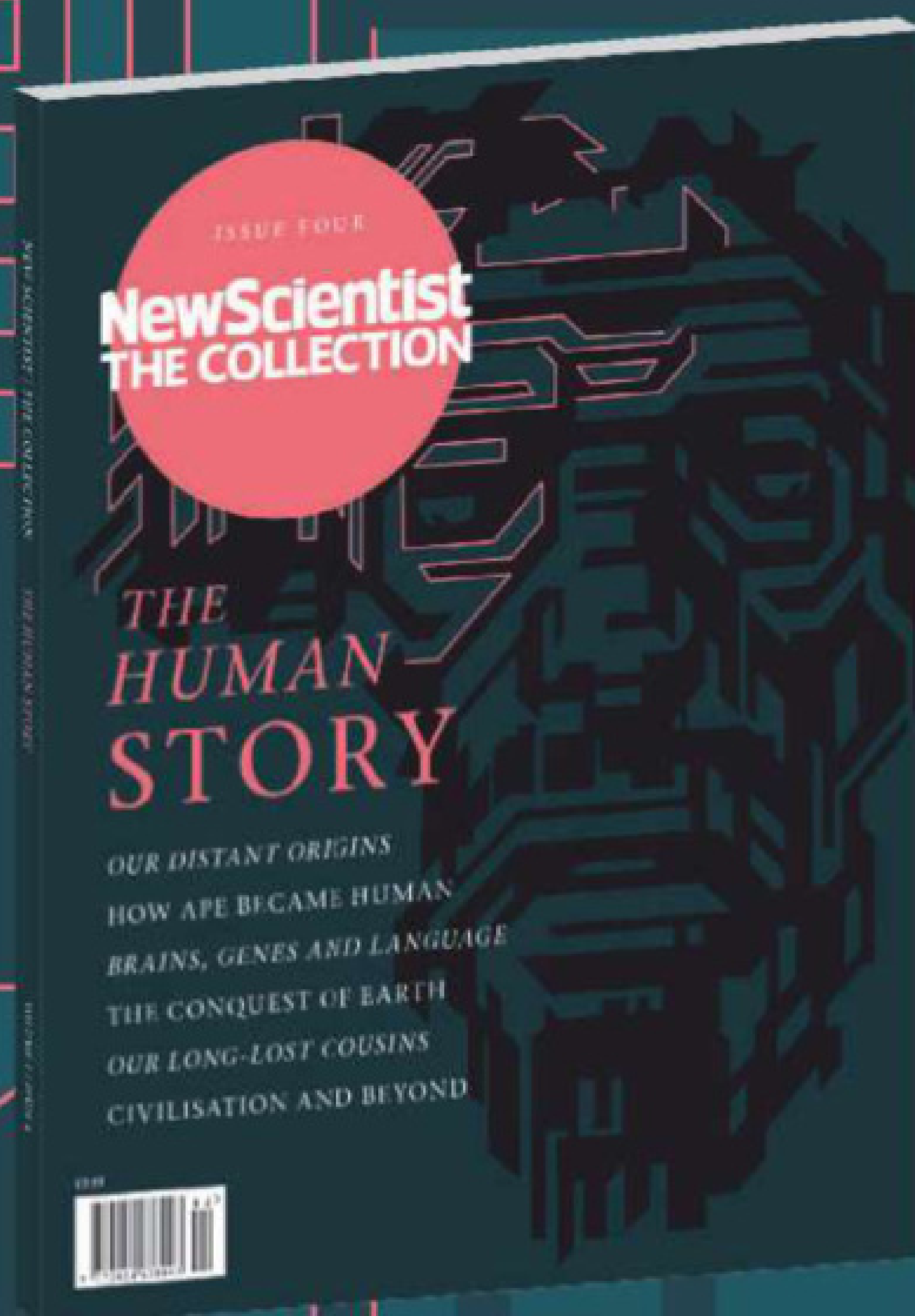
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One year subscription (51 issues) \$154

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Newsstand

Tel 212 237 7987
Distributed by Time/Warner Retail
Sales and Marketing, 260 Cherry Hill
Road, Parsippany, NJ 07054

Syndication

Tribune Content Agency
Tel 800 637 4082

© 2014 Reed Business
Information Ltd, England.

New Scientist ISSN 0262 4079 is
published weekly except for the last
week in December by Reed Business
Information Ltd, England.

New Scientist at Reed Business
Information, c/o Schnell Publishing Co.
Inc., 225 Wyman Street, Waltham,
MA 02451.

Periodicals postage pending at
Boston, MA and other mailing offices.

Postmaster: Send address changes
to New Scientist, PO Box 3806,
Chesterfield, MO 63006-9953, USA.

Registered at the Post Office as a
newspaper and printed in USA by Fry
Communications Inc, Mechanicsburg,
PA 17055



'This is our policy'

Much has changed since our first issue – but not everything

"MAY we introduce ourselves and explain our aims? It can be done quite briefly. *The New Scientist* is published for all those men and women who are interested in scientific discovery and in its industrial, commercial and social consequences. We who launch it believe we are doing so at a time when the need for such a magazine is obvious and urgent." So began the leader in our very first issue, published 58 years and one month before the one you are now reading – our 3000th.

A lot has changed. Our first issue was monochrome, dense and sober, with few hints of the vibrant design ethos we strive for today. There's little that would strike a modern reader as light-hearted, although it included a crossword by way of diversion. So does this issue, but the 2014 edition was created by a computer (see page 75).

It's not just the magazine itself that has changed: so has the context in which we operate. Most strikingly, women were hardly mentioned in our debut; today, we are closer to gender parity both among those who produce our content and those who feature in it, though there's still a way to go.

Other things haven't changed. Our original mission statement is still quite appropriate. It's an easy one to stick to, given how interesting science and its

consequences are – even if we aren't the ones labouring at the coalface of discovery.

"Scientists cherish the few true facts that they might be lucky enough to generate over the course of their careers," remarked an academic embedded with the *New Scientist* team for a month this summer. "Journalists are fact-hungry. They will procure several precious facts from a handful of different scientists before breakfast."

Life on Mars

Fortunately, those facts are in plentiful supply, although they sometimes take a long time to arrive. Our first issue included a long piece ruminating over the possibility of life on Mars – we're still trying to work that out today. Many of the concerns of 1956 are distinctly familiar: the viability of nuclear power, the persistence of the art-science divide, the extent of glacial melting and so on.

But progress marches on even when facts are elusive. Back then, we could only view Mars from afar; today we have agents reporting from its surface, even if they are robots. Another robot was at the centre of our favourite story of the year, as the Philae lander made a daring descent to comet 67/P. However, it was the human drama on the ground that

transfixed millions around the world (see page 32). Next year will see breakthroughs that would have been flights of fancy back then, from suspended animation to virtual reality (see page 21).

Ultimately, *New Scientist* – we dropped the definite article in 1961 – has endured because science and technology endure. Both are still vital to a nation's prosperity, and they will continue to be so even if nations themselves cease to exist (6 September, p 30).

So there is still an "obvious and urgent" need for our magazine – whether in print, online or elsewhere. This year has seen continuing concern about antibiotic resistance, pandemic disease, climate change and abuses of technology – issues we have covered for many years. And while some scientists have become polished communicators, others have not. Our first issue quotes one Mr Thistle, then PR man for Canada's natural research council. "I know a lot of scientists whom I love," he said, "but whose operations in the English tongue still remind me of an elephant on stilts – ponderously inelegant."

That first leader ended with this promise about the task ahead: "Our endeavour will be to perform it conscientiously – and readably." That's still what we endeavour to do today. Do join us for our next 3000 issues. ■

Down on the space farm

How are we going to get our greens in space? **Michael Slezak** reports



Dig for victory

IF YOU want to start a space farm, head for an asteroid. It seems there's enough fertiliser zipping around the solar system to grow veg for generations of space colonisers – and researchers are already beginning to grow viable, edible plants in space.

Asteroids are a hot topic with the 3 December launch of Japan's Hayabusa 2 spacecraft, which aims to return a sample from carbon-rich asteroid 1999 JU3. And astronauts are spending longer and longer in space, with the first crew to spend a full year aboard the International Space

Station due to launch in 2015.

"Longer human missions will require the company of plants, in terms of providing both food and psychological comfort," says Bratislav Stankovic at the University of Information Science and Technology in Ohrid, Macedonia. His team is one of many running experimental mini farms on the ISS, and one of the first to grow plants successfully.

Space farmers have had a tough row to hoe. Nearly every space shuttle flight through the 1980s and 1990s carried experimental plant payloads. But just as

human bodies seem to need Earth-like gravity to function, so plants seemed to struggle in microgravity.

"It appears to influence cell biochemistry," says Stankovic. The plants displayed strange genetic mutations, grew in unpredictable and undesirable shapes, and seeds did not germinate or grow well. They also had trouble producing a second generation of fertile seeds,

"Not only did the space plants produce seeds, but 92 per cent of them germinated successfully"

a key milestone for sustainable space farming.

But now, Stankovic and his colleagues from the University of Wisconsin-Madison have made a capsule that enabled two generations of seeds to successfully grow on the ISS (*Astrobiology*, doi.org/xpz).

The capsule tightly controlled soil moisture, light, air temperature, humidity, and levels of carbon dioxide and ethylene – a hormone plants release into the air when they begin to ripen. A mesh held down a base of fertilised gravel in which the

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plants could spread their roots.

Once astronauts installed the system, it was remote-controlled and monitored from the University of Wisconsin. They grew *Arabidopsis thaliana*, a small, edible flowering plant that is often used as a model species.

Not only did the plants produce seeds, but 92 per cent then germinated successfully. Some were grown on the ISS and others back on Earth. There was little difference between the two, the team found. The space seeds had their protein stores packed a little differently and the plants' branches grew in slightly different directions. But these are small details, Stankovic says. "It is likely that the previous failed attempts had to do with inadequate control of the growth environment," he says. "Microgravity per se is not a limiting factor."

No gravity required

Other would-be space farmers have focused on characterising differences more precisely. Robert Ferl at the University of Florida in Gainesville and his colleagues also grew *A. thaliana* on the ISS.

They found that plants used adaptive strategies to deal with not having gravity, such as increasing their expression of genes associated with light perception in the leaves and remodelling root cell walls.

Understanding those strategies could help engineer plants that grow even better in space than they do here, says Ferl. Still, that might not even be necessary, he says, since plants seem to find solutions themselves.

"I remain optimistic that before the end of the decade we will obtain seeds from plants grown on the moon," Stankovic says. But that raises an important question: will lunar soil support plants?

Plants grown on spacecraft will need soils we bring with us and will be able to use human waste as fertiliser. Ongoing extraterrestrial colonies are another story, though.

If off-Earth colonies want to grow, or if they can't recycle every last atom of waste, we will need additional nutrients. "Get to Mars or the moon and, yes, plants will pull minerals from whatever soils we give them," says Ferl. "Any atoms that plants pull, we don't have to pack."

Although the Apollo missions carried out plant experiments using lunar regolith, which is mainly composed of basaltic and other volcanic material, there were not enough experiments to get an idea of whether it would be suitable, Ferl

says (*Astrobiology*, doi.org/c52fbn).

Other groups have tried growing plants in simulated lunar and Martian soil, whose mineral composition is similar to volcanic Earth soils. Wieger Wamelink and colleagues at the Alterra research institute, part of the University of Wageningen in the Netherlands, reported this year that they grew a veritable salad – wheat, tomato, cress and mustard – for 50 days with no added nutrients (*PLoS One*, doi.org/xp3). The plants even grew better in the simulated space soil than controls grown in poor quality Earth soil.

Looking even further forward, others have pondered how large human populations might sustain themselves in space. That's where asteroids come in, specifically carbonaceous or "c-type"

"Some asteroids are highly nutritious and could sustain farms for large human populations"

asteroids, which are known to be packed with organic compounds.

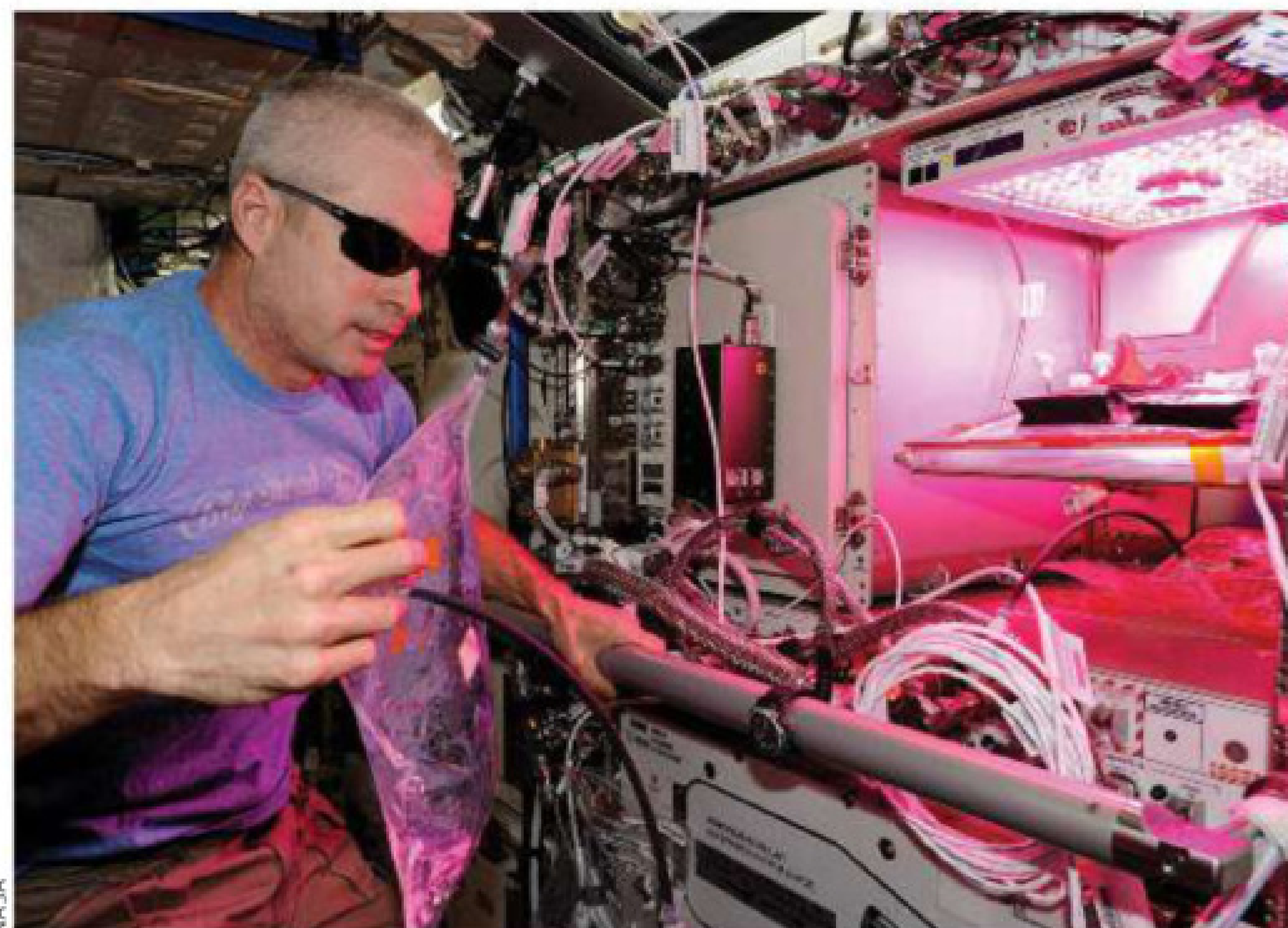
They are highly nutritious for plants, according to Michael Mautner of Lincoln University in New Zealand. He has grown edible plants directly in material from c-type asteroids, which fell to Earth in meteorites. He simply ground up the meteorite and added water.

He has also analysed the nutrient content of these meteorites and extrapolated to asteroids. He calculated that a 200-kilometre-wide space rock could provide enough fertiliser to sustain 10,000 people for a billion years (*Planetary and Space Science*, doi.org/xp6).

You'd need to control the air pressure and provide water, but the nutrients are there, he says. If we grabbed all the carbonaceous asteroids in the solar system, it could sustain a population of a billion for a billion years, according to his estimates.

Both Stankovic and Ferl say Mautner's work is useful, quantifying the long-term vision of nutrients availability for space farming. "There are great resources in space that can yield immense human populations in this solar system, and much more in billions of solar systems in the galaxy, for billions of future aeons," Mautner says.

But we can't count our space lettuces before they germinate, Maunter warns. This vision relies on the success of the home planet. "For this future, we must make secure our human survival on Earth first, so that we can spread life in space." ■



NASA

HOW DOES YOUR GARDEN GROW?

All sorts of plants and seeds have already been to space and back. Here are a few highlights.

- In the first space walk by an American, Ed White carried mustard seeds as a sign of his Christian faith.
- Stuart Roosa took 500 seeds of various kinds on Apollo 14, which orbited the moon. On return, the seeds were grown alongside controls. No differences were seen.
- Seeds were kept for 72 days aboard the first space station, the Russian Salyut 1 in the early 1970s, providing the first observations of seed germination after space flight.
- In the early 1980s, the Russians grew lettuce on Salyut 7.
- Dozens of plant species have been grown on space shuttle flights. Potatoes grew the same in space as they do on Earth.
- Other space shuttle plants include sunflowers, cress, oats, pine and mung beans. Some plants' roots grow in the wrong direction without gravity but others don't.
- A second generation of canola seeds was grown aboard the International Space Station, but they were not very healthy.
- In what may be a prelude to astronauts eating fresh-grown space produce, Chinese cabbage, Swiss chard, lettuce, snow pea and radish are currently growing aboard the ISS.

Point and zap to iron out diabetes

Clare Wilson

A RADIO-CONTROLLED mouse might sound like a child's toy, but this version is flesh and blood and not for playing with. Genetically altered mice have shown that it is possible to regulate processes within the body remotely, opening the door to new ways of treating chronic disease.

Remarkably, the mice can respond to a radio signal by releasing insulin, which lowers blood sugar. One day this might allow people with type 1 diabetes to use an app on their phone to alleviate their disease at a cellular level. Jonathan Dordick of the Rensselaer Polytechnic Institute in New York, who was part of the team that carried out the work, says you can imagine tailoring the technique to treat other disorders, too.

The approach relies on the presence of iron particles, which can absorb energy from radio waves of the right frequency, changing cell behaviour.

To test the concept, the team introduced three genes into mouse liver cells. One encoded an iron-containing protein called

ferritin. This was placed next to a gene that coded for a protein that acts like a heat-sensitive door, allowing calcium to surge into the cell whenever ferritin was exposed to the radio signal.

The third gene coded for insulin but was only active when there

was a flood of calcium.

The team hoped this set-up would allow radio waves to trigger insulin release. Sure enough, the engineered mice showed a significant drop in blood glucose for several hours after being exposed to the radio signal (*Nature Medicine*, DOI: 10.1038/nm.3730).

The work is a long way from being used therapeutically in people, but Dordick says it is a first step to offering fast external control over many conditions. In

Parkinson's disease, for instance, the same approach could be used to lessen jerky movements by delivering dopamine to the brain.

"If it is true that ferritin could be used, this is very good news," says Arnd Pralle of the University at Buffalo in New York, although he cautions that further work is needed to confirm the results.

Gene therapies are still seen as an irreversible and potentially risky option, so are being investigated only for conditions that remain hard to treat, such as haemophilia and certain types of blindness. But team member Jeffrey Friedman of Rockefeller University in New York says radio control could make such therapies safer, as the introduced gene could be turned on and off as necessary.

What's more, as well as genetically altering liver cells inside mice, the team got the approach to work by modifying mouse stem cells in a dish, then implanting them back into the animals. Such implanted stem cells could be given a "suicide gene" that can be activated to kill them off if they start causing dangerous side effects, says Friedman – another concern with gene therapy.

"Lots of different pieces are coming together at the moment," says Dordick. "The exciting thing here is the ability to have remote control over the body." ■



Send a radio signal instead

Oh no, it's déjà vu all over again ... and again

HAVE you read this before? A 23-year-old man from the UK almost certainly feels like he has – he's the first person to report persistent déjà vu stemming from anxiety rather than any obvious neurological disorder.

Nobody knows exactly how or why déjà vu happens, but for most of us it is rare. Some people experience it more often, as a side effect associated

with epileptic seizures or dementia.

Now, researchers have discovered the first person with what they call "psychogenic déjà vu" – where the cause appears to be psychological. The man's episodes began just after he started university, a period when he felt anxious and was also experiencing obsessive compulsions. As time went on, his déjà vu became more and more prolonged, and then fairly continuous after he tried LSD. Now, he avoids television and radio, and finds newspapers distressing as the content feels familiar.

There are different theories as to

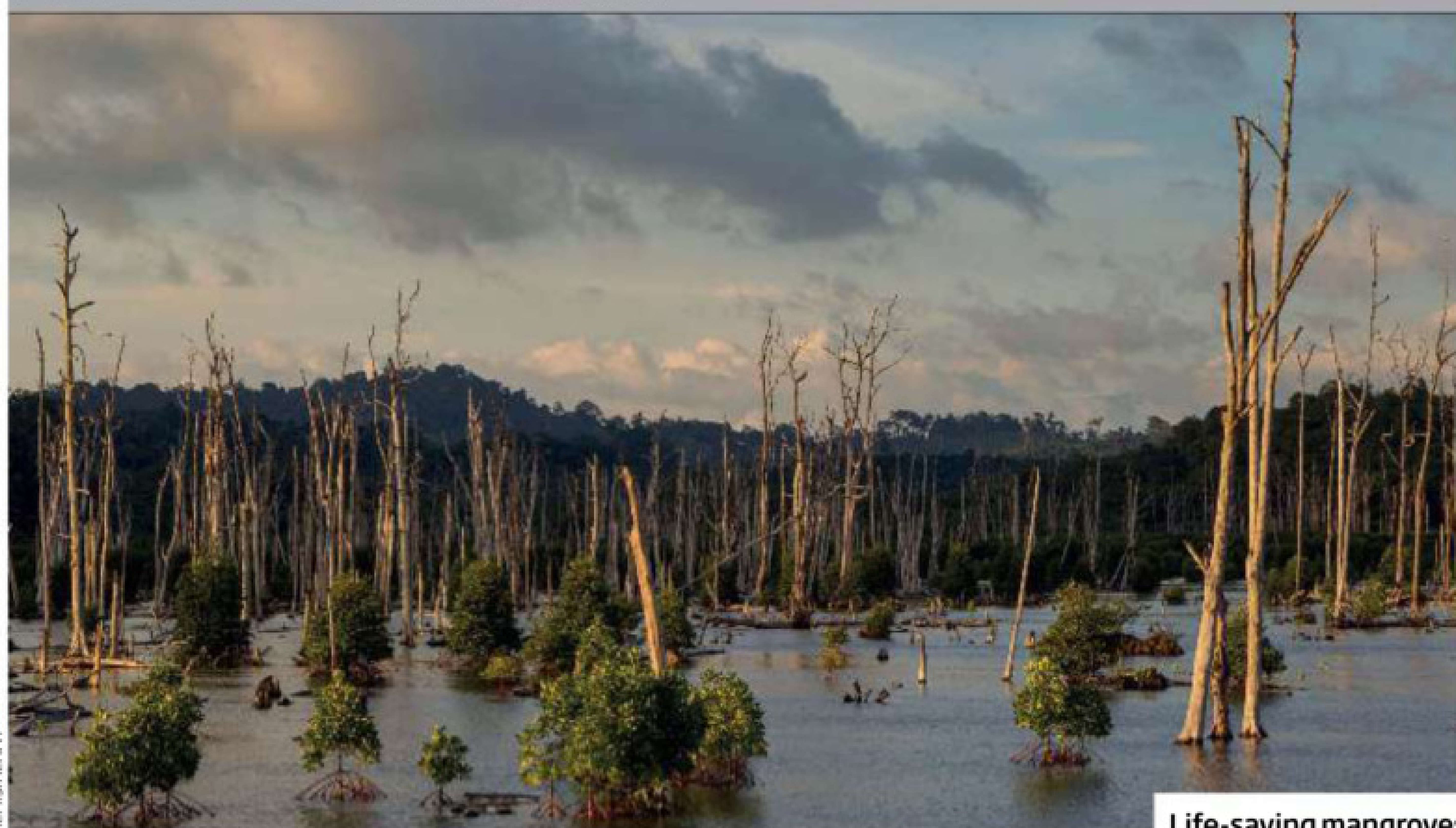
what is going on, says Christine Wells at Sheffield Hallam University in the UK, who has written a paper on the man's experiences. "The general theory is that there's a misfiring of neurons in the temporal lobes – which deal with recollection and familiarity. That misfiring during the process of recollection means we interpret a moment in time as something that has already been experienced," she says.

"It's a vicious cycle: anxiety causes his neurons to misfire, which triggers déjà vu, which leads to anxiety"

Surprisingly, when Wells gave the man a standard recall test, he scored more similarly to people of his own age without the condition than those with epilepsy-related déjà vu. An MRI and an EEG scan of his brain activity also showed no abnormalities.

It may be that his anxiety is causing a misfiring in the brain, which causes the déjà vu and in turn causes him more anxiety. "It's a vicious circle," says Wells, who is investigating other cases of anxiety to see if anyone else has reported something similar (*Journal of Medical Case Studies*, doi.org/xpv). Helen Thomson ■

FIELD NOTES Aceh, Indonesia



Life-saving mangroves

Ten years after the tsunami

Fred Pearce

THE worst tsunami on record hit South-East Asia on 26 December 10 years ago, killing more than 227,000 people in total. I recently toured villages on the west coast of Aceh, the Indonesian province that bore the brunt of the impact, where 167,000 lost their lives when a 20-metre wave crashed ashore that morning. I also saw the results of heavy mangrove reforestation since the tsunami.

Can replanting mangrove forests on tropical coastlines really protect communities from the immense destruction of a tsunami such as the Indian Ocean killer wave that struck 10 years ago?

My guide was environmental scientist Agus Halim whose wife and two children died in the disaster. He helped mastermind ecological reconstruction of the damaged coastlines for the Indonesian government, and was clear in his answer. "They are very important for protecting coastal areas, because they can absorb

wave energy," he says. And, thanks to the thousands of hectares of mangroves planted round Aceh since the tsunami, next time they would do the job – or at least, that's the hope.

The tsunami was caused by an earthquake just offshore. In the fishing village of Keude Unga, an old man in a cafe told me that the wave was higher than the trees. "Every building in the village was destroyed. The only people who survived were those who ran for the hills," he says. In some of the villages, nobody survived.

Nothing could have prevented massive destruction, nor stopped the permanent sea invasion that followed. The quake caused widespread land subsidence that shifted the shoreline inland by up to 800 metres and left the sites of villages, such as nearby Gle Jong, permanently submerged.

There is growing evidence that even under such extreme circumstances, mangroves' dense root and branch networks could help dissipate tsunamis, reducing their devastation.

Some early claims for the protective effects of mangrove forests in 2004 have been debunked as statistically unreliable, because there are too many variables to allow easy conclusions, such as difference in beach slopes or coast angles (*Estuarine, Coastal and Shelf Science*, doi.org/bvd8ms).

But others are more robust, says Halim. A study found villages behind mangroves survived best (*Science*, doi.org/b564c7). And

"Mangroves in front of settlements resulted in 8 per cent fewer casualties during the tsunami"

detailed analysis of satellite images of the west coast of Aceh by Juan Carlos Laso Bayas of the University of Hohenheim, Stuttgart, Germany, suggests that forests in front of settlements resulted in 8 per cent fewer casualties during the tsunami (*PNAS*, doi.org/c6wrbg).

That figure sounds modest, but it represents perhaps 10,000 lives.

And it could be conservative. Experiments by Tetsuya Hiraishi and Kenji Harada of Kyoto University, Japan, showed that a 100-metre belt of dense mangroves could reduce the destructive energy of a tsunami by as much as 90 per cent.

The tragedy is that, as in many places across the tropics, most of Aceh's mangroves had been uprooted before the tsunami, to make way for shrimp ponds.

Since 2004, many NGOs have tried to replant the trees. Perhaps the most successful has been the Green Coast project supervised by Halim and run by two NGOs based in the Netherlands, Wetlands International and Oxfam Novib. In return for planting trees, survivors were offered collateral-free loans to help start post-tsunami businesses in their villages. Wetlands International agreed to write off the debts if 75 per cent of the trees survived for two years. This was critical for the project's success, says Wetlands' Indonesian director Nyoman Suryadiputra.

That target was achieved almost everywhere. Close to 2 million trees have been planted around 70 villages. This included mangroves on mud, and fast-growing native casuarina pines on sandy areas.

The foreign aid groups left Aceh five years ago. Most of the projects started with Green Coast credit, including cafes, fishing boats and cattle-rearing farms, are doing well. Life is returning to normal. There seems to be a baby boom. Halim married again and has a child. We watched the boy play in the sand as we ate lunch at a beachside restaurant.

The science, reiterated in a UN report on mangroves in September, suggests the villagers of Aceh can be reassured that the trees will provide some protection from the ocean. But if they ever hear the roar of an approaching tsunami again, they should head for the hills as fast as they can. ■

Mind. Full!

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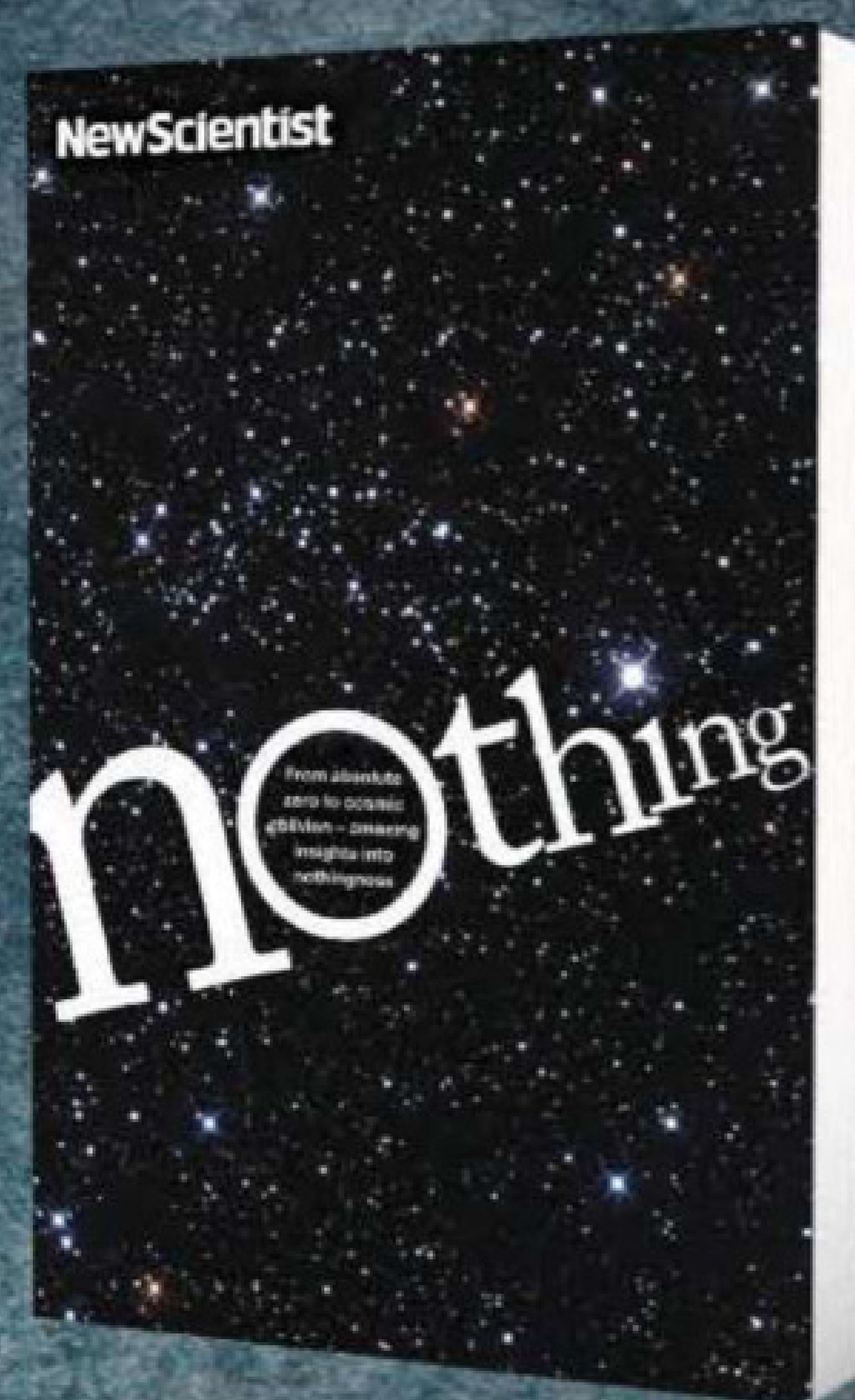
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Bright chick plays tricks on would-be predators

FOOL me once, shame on you. Fool me twice, I don't eat you... The chicks of the cinereous mourner (*Laniocera hypopyrra*), a drab grey bird from South America's tropical forests, look - and act - like a poisonous species of caterpillar to avoid being eaten by snakes and monkeys.

Gustavo Londono, now at the University of California, set up cameras to observe what happens inside the birds' nests in the Peruvian Amazon. Cinereous mourner parents spend a lot of time foraging away from the nest, which gives ample time for predators to eat chicks in a habitat where predation can be as high as 80 per cent.

To try to prevent being eaten, the chicks have bright orange feathers, with a tip of white (see photo), which when they lie down makes them look like a caterpillar. They assume any arrival to the nest, including a parent, is a predator and so they start moving their head from side to side, giving the appearance of a sliding caterpillar (*American Naturalist*, doi.org/xpk).

Movement and appearance combined would probably be enough to deter predators, Londono says. But the just-hatched chicks have another trick up their sleeve. Their bright orange colour could double as camouflage, as they blend in with the dried leaves lining the nest. "Mimicry plays a major role in deterring predators, but camouflage is also likely to occur when the nestling is on the nest," says Londono.

"Mini-LHC" ramps up to record energy

TABLE-TOP particle accelerators can now rival the real thing. A laser-powered device just centimetres long can boost electrons to energies previously seen only in giant smashers.

The world's biggest accelerator, the Large Hadron Collider at CERN near Geneva, Switzerland, is a 27-kilometre ring that next year will slam particles together at energies of 13 teraelectronvolts

(see page 23). But even standard-size facilities require tunnels hundreds of metres long to reach gigaelectronvolt (GeV) energies.

Physicists have been working to develop accelerators that could run on an ordinary lab bench. Now Wim Leemans of the Lawrence Berkeley National Laboratory in California and his colleagues have got particles in their 9-centimetre-long device

up to 4.2 GeV (*Physical Review Letters*, doi.org/xpr).

The trick is to use a high-powered laser pulse to create waves in a plasma, which electrons can ride like surfers. The team were able to better control their waves than in previous table-top accelerators, letting them build a longer tube and thus reach higher energies. More advanced lasers are needed to sustain the pulses before big facilities can be replaced, says Leemans.

How DNA folds itself into our cells

MANY things look clearer in 3D, and that goes for genomes too.

The human genome was sequenced about 10 years ago, but we still have a lot to learn about its structure and function. One puzzle was how the 1.8 metres of our DNA fits into our cell nuclei, which are 10,000 times shorter.

Now the way our genetic material folds and loops in on itself has been mapped in unprecedented detail in nine cell types, including immune, lung and skin cells. The work is the first draft of the 3D genome, also known as the "loopome".

It is important to map these undulations because where a gene ends up and what it is next to can influence whether it is active. "The loopome will lead to amazing insights into how cells work, normally and in disease," says team member Suhas Rao of Baylor College of Medicine in Houston, Texas (*Cell*, doi.org/xqj).

We share singing genes with birds

CHRISTMAS carollers rejoice: you sing like a bird. Genes involved in vocal learning in humans are also active in some birds, but are not found in other animal species.

Researchers looked at maps of gene expression in the brain tissues of birds that can learn vocals and those that can't, and compared them with expression maps in human brains. They found 55 genes that show a similar pattern of activity in the brains of humans and vocal-learning birds (*Science*, doi.org/xqh).

Such systematic similarities mean that songbirds could be used to study disorders that affect speech, such as Huntington's disease, says Andreas Pfenning from the Massachusetts Institute of Technology.

Christmas trees get cold feet

OUR warming climate is bad news for Christmas trees. Norwegian spruces risk getting cold feet as the insulating blanket of snow that protects their roots from Scandinavian winters thins.

Snow can be surprisingly cosy – acting like loft cladding to prevent sub-zero air penetrating the soil. Less of the white stuff means frigid soil that takes longer to thaw in spring. This limits trees' new growth and ultimately has a knock-on effect on health, says Sirkka Sutinen of the Finnish Forest Research Institute in Joensuu.

Sutinen and her team spent two seasons studying a clump of 47-year-old spruces in eastern Finland. They simulated the effect of a thinner snow pack by allowing the soil to freeze then applying insulation to prevent it thawing as quickly. When the thaw was delayed until mid-summer, buds opened much later, and fewer, smaller pine needles sprouted (*Forest Ecology and Management*, [doi.org/xpn](https://doi.org/10.1016/j.foreco.2014.08.011)).

These conditions were more extreme than happen naturally, but modelling studies hint that lower snowfall is possible in the near future. "If the climate changes how we expect it to, the trees are not going to be happy," Sutinen says. "If we had several years like this in a row, we could see significant damage".



DOP USA/REX FEATURES

DIY device to define the kilogram - using Lego

WANT to measure a fundamental constant in the comfort of your own home? Grab a pile of Lego and get building. Just in time for Christmas, researchers at the US National Institute of Standards and Technology (NIST) have provided instructions for a Lego watt balance, which can fix the official value of the kilogram.

At the moment the kilogram is defined in relation to a lump of metal in a basement in Paris – not the most reliable measure. One way to improve this is to define it in terms of the fundamental

constants. This can be done using a watt balance, which measures weight in terms of voltage and current, which depend on the Planck constant.

Xiang Zhang and his colleagues say their \$650 Lego version can make this measurement with an uncertainty of 1 per cent – not as good as ultra-precise watt balances with an uncertainty of 1 in 100 million, but much cheaper.

The Lego device looks a bit like a traditional set of scales, with weighing pans on either side. It's not totally made from plastic

blocks, though – you also need coils of wire beneath the pan and strong neodymium magnets nearby to make a measurement (arxiv.org/abs/1412.1699).

Finding the mass requires two measurements. First place a weight on one of the pans, moving the coil past the magnet and inducing a voltage. Then run a current through the coil, creating an electromagnetic force on the pan that counteracts the weight. Comparing these two gives you the weight's mass, which can be compared to the Planck constant.

Bacterial powder stops weight gain

YUCK. It's not appetising, but an edible powder made from the waste secretions of gut bacteria seems to stop people gaining weight by making them feel full.

When we digest fibre, the bacteria in our guts secrete a fatty acid called propionate, which activates the release of satiety hormones. But to trigger the release of enough hormones to significantly suppress appetite, people would have to eat extremely large amounts of fibre.

Gary Frost of Imperial College London and his colleagues have made a more concentrated form of the molecule, called inulin-propionate ester. "That gives you eight times the amount of someone following a typical Western diet," says Frost.

Stabilising a person's weight could have a big health impact, says Frost, because as people on Western diets grow older, they gain an average of 0.3 to 0.8 kilograms a year. The powder, when drunk daily mixed in with fruit juice or a milkshake, helped dozens of overweight volunteers stick to their weight over six months, while people given fibre alone packed on the pounds (*Gut*, [doi.org/xqk](https://doi.org/10.1136/gut.2014.284111)).



JONAS BENDIKSEN/MAGNUM

Glaciers control a mountain's height

WHY are mountains only as high as they are? Part of the answer is that they are kept in check by a process known as the glacial buzz saw.

When glaciers form on a mountain, they carve amphitheatre-shaped hollows into them called cirques. Sara Gran Mitchell, a geologist at College of the Holy Cross in Massachusetts, and Elisabeth Humphries at the University of North Carolina at Chapel Hill measured the elevation of 14,000 cirques, now free of ice, around the world.

They found that mountain summits rarely rose more than

600 metres above the highest cirque. They also found that cirques, and peak heights, were higher near the equator and lower at the cooler high latitudes (*Geology*, [doi.org/xpt](https://doi.org/10.1130/G35811.1)). This suggests that cirques – and hence climate – play a crucial role in limiting the height of mountains.

Gran Mitchell says cirques may act as a "glacial linebreaker" that takes mountains out at the knees. The glacier scours the floors of the cirque and eats away at the walls, steepening the slopes above and making them weak and prone to erosion.

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Meet your AI assistant

By handling a host of mundane daily tasks, artificially intelligent helpers are poised to make life a lot easier

Hal Hodson

AMY emailed me three times overnight, roughly once every 3 hours between 2 and 8 am. She's setting me up on a call with Dennis Mortensen, head of X.ai, the startup company that built her. While her email address looks just like anyone else's, her unusual persistence betrays her true identity. Amy is an artificially intelligent personal assistant designed to automatically set up meetings for its owner.

Amy's architects are part of a growing cadre of researchers and startups that want to hand over to machines many of the scheduling tasks that humans have traditionally had to look after.

Amy is made to be easy to use: anyone who signs up to the service simply copies in Amy on an email and it takes over the scheduling, recognising phrases like "sometime next week" or "next Wednesday". Amy looks at the user's calendar and figures out when they are free for meetings. It then sends requests to the other person, or perhaps their AI assistant, asking questions to find out when they are available. When it finds a mutually suitable time, it sends out a calendar invite, hopefully saving two people from using up their time playing email ping-pong.

Ankit Agarwal, who runs a startup called Micello that makes indoor maps, says he now uses Amy instead of a human assistant for all scheduling tasks. "Amy has set up hundreds of meetings for me," he says. "It's one of those magical services where you CC Amy and it gets done."

The system is designed to work

with any communication system – SMS or voice, not just email, Mortensen says. And while it only works for scheduling right now, in future it could expand to control things like smart home appliances and robots.

Sriraam Natarajan of Indiana University in Bloomington says AI assistance could be incredibly useful in hospitals. An intelligent triage system, for example, could handle the influx of patients on its own, using digital health records and symptoms databases to offer more complete analyses than doctors and nurses often have time for.

"Think about entering a hospital," Natarajan says. "The physician asks a few questions – did I have an injury in the past five years? My answer will probably be no because I don't remember. How cool would it be if a system steps in and notes that I do have a certain preexisting condition?"

"Given the growth of electronic health records, and that hospitals are linking records together, I think it's possible in the near future," says Natarajan.

Other assistant services are looking to help out in other areas of life. For example, an app called Humin was launched outside the

US on 9 December. It aims to help you remember people you meet and predict who you might like to contact by tying their details into the context of your relationship. This lets you search for "people I met last week", say, just like you might ask a friend about someone you met at their party.

Google Now, Siri and Microsoft's Cortana assistants all contain a machine learning component that allows for similar predictive services, like scanning your email and notifying you of upcoming flights you've booked.

"The app can search for 'people I met last week', like asking a friend about someone at their party"

For AI assistants to perform these tasks, they have had to take an important step in understanding language and how humans communicate, including common phrasings like "how about we set up a chat", as well as distinguishing time and place names.

As Amy's overnight missives to my inbox attest, there is still much about human behaviour that machines don't grasp. But, as Mortensen points out, such pestering ensures that a meeting isn't missed. And if an AI assistant can competently take over these small, mundane jobs, he says, it will free up our brain power for more productive purposes.

And while we are very far from building computer intelligence on anything approaching a human level, Mortensen thinks that developing many smaller applications like Amy into a mesh of services that all talk to one another may one day provide a sort of super-helper, with each specialised bit of software tackling a narrow facet of daily life better than a human.

"If you assemble those companies together a decade from now, we might have something that looks like the AI we were promised," Mortensen says. ■



CJ BURTON/CORBIS

Too much to think about

Computer says cheetah

Machines can be tricked into seeing things, finds **Jacob Aron**

COMPUTERS can identify objects with near-human levels of accuracy, enabling them to do everything from creating picture captions to driving cars. But now a collection of bizarre optical illusions has revealed that machines don't see the same way we do, which could leave them vulnerable to exploitation.

Image-recognition algorithms learn to recognise objects by analysing numerous images and identifying patterns that mark out a cat from a coffee cup, for example. Jeff Clune of the University of Wyoming in Laramie and his colleagues wanted to know whether a particular type of image-recognition algorithm called a deep neural network (DNN) could be linked to a genetic algorithm that uses a natural selection-like process to evolve pictures.

Such algorithms, with humans rating and thus guiding their results, have previously created images of apples and faces, so Clune expected that replacing the human with a DNN would work just as well. "Instead we got these

rather bizarre images: a cheetah that looks nothing like a cheetah," Clune says.

Clune used one of the best DNNs – AlexNet, which was created in 2012 by researchers at the University of Toronto, Canada. Its performance is so impressive that Google hired the team behind it last year.

It turned out that the genetic algorithm produced images of seemingly random static that AlexNet declared to be depictions of various animals with more than 99 per cent certainty. Other images, generated in a different way, look like abstract art to humans but fool AlexNet into seeing a baseball, electric guitar

or other everyday object.

The algorithm's confusion is due to differences in how it sees the world compared with humans, says Clune. Whereas we identify a cheetah by looking for the whole package – the right body shape, patterning and so on – a DNN is only interested in the parts of an object that most distinguish it from others. Focusing on these elements, rather than the image as a whole, leads the DNN down the wrong path. "It's almost like these DNNs are huge fans of cubist art," says Clune.

Studying these illusions and the differences between algorithms and humans could teach us more about ourselves, says Jürgen Schmidhuber of the Dalle Molle Institute for Artificial Intelligence Research in Manno, Switzerland. "These networks make predictions about what neuroscientists will find in a couple of decades, once they are able to decode and ready the synapses in the human brain."

More immediately, Clune wants to figure out how to help DNNs ignore the illusions. If DNNs can be fooled by static, an attacker may be able to bypass facial-recognition security systems or even trick driverless cars into seeing misleading road signs. "It opens any application that uses this computer vision up to security hacks," he says. ■



Spot the big cat

Smart shoes with lasers make strides in mobility

THE right shoes can do more than complement your outfit. A new mobility aid named Path helps people who have trouble walking – simply by being fitted to their shoes.

Lise Pape, an engineer at InnovationRCA at the Royal College of Art in London, was inspired to build the system by her father, who was diagnosed with Parkinson's

disease more than 10 years ago. Like many people with Parkinson's, he falls occasionally and experiences freezing of gait, the temporary impression that his feet are glued to the ground.

Visual cues have been shown to improve the pace and extend the stride of people with Parkinson's. So a laser that Path adds to the tip of the shoe projects parallel lines onto the next 50 centimetres of the floor. Each shoe lays down a guide for the opposite foot, keeping the grid steady until the wearer is ready to take the next step.

In addition, pressure sensors

inserted into the soles of the shoes trigger vibrations when a foot hits the ground. This active feedback is designed to compensate for loss of sensation in the feet, another common symptom of Parkinson's. The soles and the toe projectors can easily be fitted to an ordinary pair of shoes.

Earlier this year, Pape tested Path on one person with Parkinson's and two with multiple sclerosis, another

"One shoe projects a guide for the other, keeping the grid steady until the user is ready for the next step"

disease that impairs movement. The preliminary results were presented on 10 December at the Footwear Health Tech Conference in Eindhoven, the Netherlands. "I've had a lot of encouraging feedback from patients," Pape says. She plans to run a clinical trial early next year and wants to explore how the shoes can help people with spinal cord injuries.

"It's a great idea," says Peter Schmidt of the National Parkinson Foundation in Miami, Florida. He says projected lines are a great aid, but up until now they've only been built into canes and walkers. Aviva Rutkin ■

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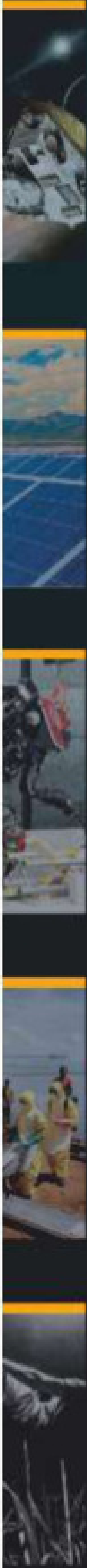
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CHEATING DEATH Saved by suspended animation

BODY HACK The ultimate makeover

PLUTO'S FIRST CLOSE-UP

In an age where robots tweet selfies from the moon, Mars and a comet, it might come as a surprise that we barely even have a picture of Pluto. That's set to change next year, when NASA's New Horizons probe pays humanity's first visit to the distant dwarf planet.

Our current best snapshot of Pluto is just a handful of pixels captured by the Hubble Space Telescope. With clever processing, astronomers have turned these into a blurry map splattered in orange and black, a tantalising glimpse of what's to come.

New Horizons will get close enough to match Hubble's resolution between February and May. But the real glamour shots will come on 14 July, when the probe reaches its closest approach at around 10,000 kilometres above Pluto's surface - closer than some satellites orbit Earth.

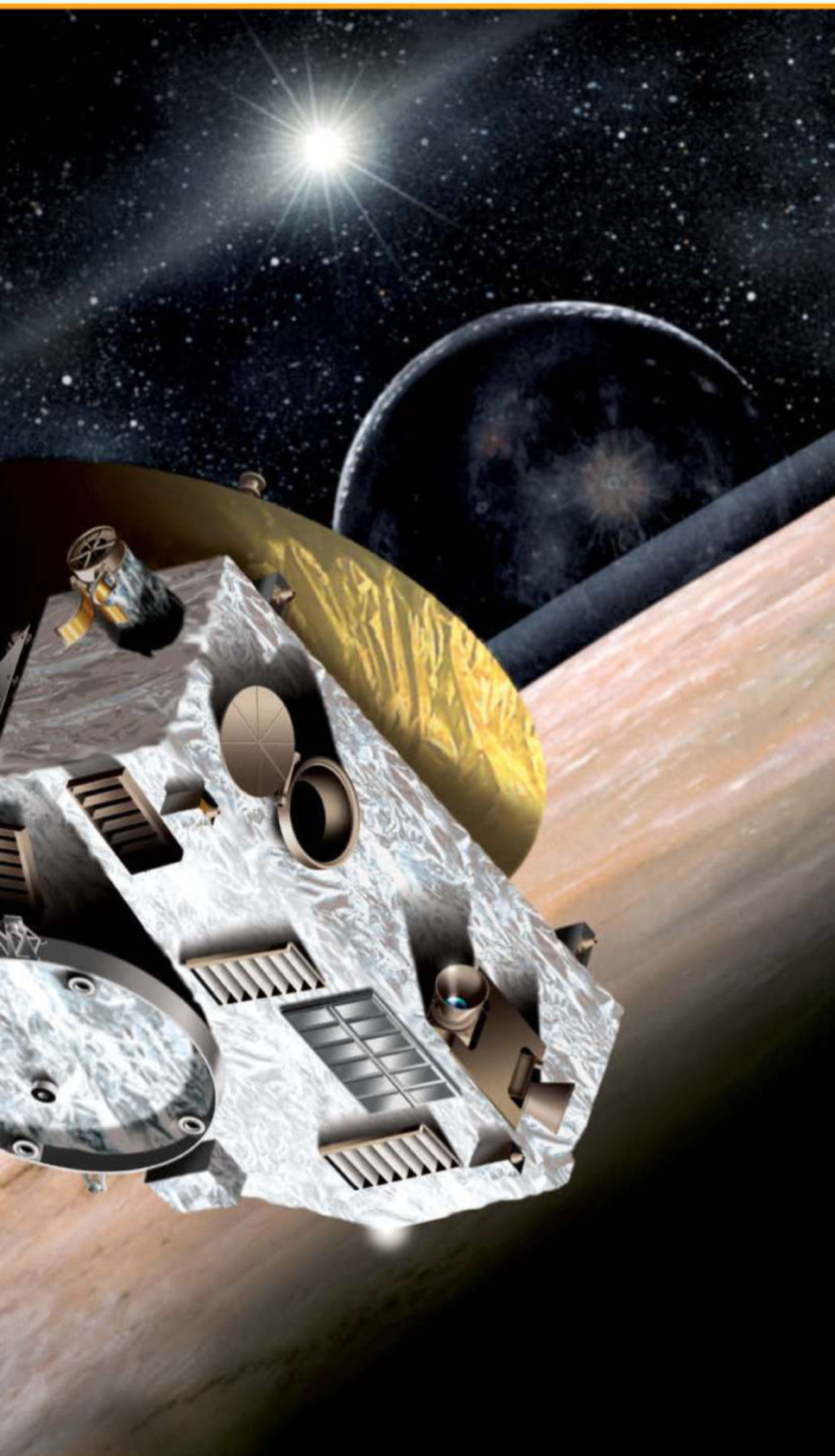
With no ability to slow down, New Horizons will whip past Pluto and continue on to the outer reaches of the solar system, watching the dwarf planet recede in its rear-view mirror.

This brief visit has been a long time coming. New Horizons launched in January 2006, when Pluto was still the solar system's ninth planet. It was downgraded to dwarf planet status later that year, much to the chagrin of lead scientist Alan Stern, who has been campaigning for its reinstatement ever since. The probe's arrival could boost the campaign, after the debate was reignited by the 2012 discovery of two new moons, upping Pluto's satellite count to five.

New Horizons is equipped with a host of instruments besides its camera, and the vast amount of data it will collect will take over a year to transmit to Earth. But as someone too young to remember our last deep-space probe, Voyager 2, encountering Uranus and Neptune in the 1980s, I can't wait to see the first images of a new world. See you soon, Pluto. Jacob Aron

"As someone too young to remember our last deep-space probe, I can't wait to see the first images of a brand new world"





REBOOTING THE PARTICLE SMASHER

"Try turning it off and on again" is a common piece of tech advice, but when you are dealing with the world's biggest machine, things aren't so simple.

Researchers at CERN near Geneva are getting ready to reboot the Large Hadron Collider, which was shut down in February 2013 to prepare it for colliding beams of protons at higher energies. The full switch-on is set for May 2015.

The LHC has performed well so far: in 2012 it discovered the Higgs boson, the last missing piece of the standard model of particle physics. But as the reboot approaches, some physicists worry that their machine won't find anything else.

We know that the standard model is an incomplete description of the universe - it has nothing to say about gravity, for example. So there must be a more all-encompassing theory out there. It was hoped that the Higgs might have a few personality quirks to point physicists in the right direction, but it is looking more and more like the bog-standard version the standard model predicts.

One of the standard model's leading competitors is a theory called supersymmetry, or SUSY, which posits the existence of a heavier partner for all of the standard particles. But no such particles have yet turned up.

If running at higher energies fails to find any superpartners, it will leave physicists with a multibillion dollar dilemma: should they build a successor to the LHC, capable of higher-energy collisions that might reveal SUSY? Or should they abandon SUSY in favour of something new? With no particles to show theoreticians the way, that decision won't be easy, and no amount of switching the LHC off and on again will help. Jacob Aron

CLIMATE FOR OPTIMISM

It's easy to be bored stiff by the ins and outs of climate policy, but wait! Before you ignore yet another climate summit - planned for Paris next December - consider the bigger picture: you are witnessing a complete transformation of the world around you. The next few years will be written about in history books.

We're changing the juice we use to run our civilisation. Solar panels are becoming more affordable. China is shutting down power stations. The least polluting of all fossil fuels - methane - is now also the cheapest. We can build energy-neutral houses. Many Western countries have feed-in tariffs so you can get paid for pumping the extra energy generated by the panels on your roof or turbine in your backyard into the grid. In Germany, so much solar energy is fed into the grid that it may cause black-outs. Yes, that's right: Germany's grid could overdose on renewable power.

And politics? Since the Copenhagen climate

fiasco of 2009, many countries have introduced climate legislation, including the world's biggest polluters. Unhindered by re-election concerns, Barack Obama has introduced the first US climate policy, including its first ever emissions target. This year the Chinese leadership spoke of peaking emissions. That's huge news. The US and China also have joint research projects on green energy. There are even rumours that OPEC states whose wealth is built on oil are thinking of shifting money into renewables.

So yes, the world is warming faster than ever before and the seas keep rising. The consequences will be catastrophic. But before you despair, look around you. Change is afoot and it's better to harness that drive than wallow in the doom and gloom.

So think of that when world leaders assemble in Paris to reach a global agreement to curb climate change. The world will never be the same. Catherine Brahic

"Change is afoot and it's better to harness that drive than wallow in the doom and gloom"



RIISING STARS OF HUMAN HISTORY

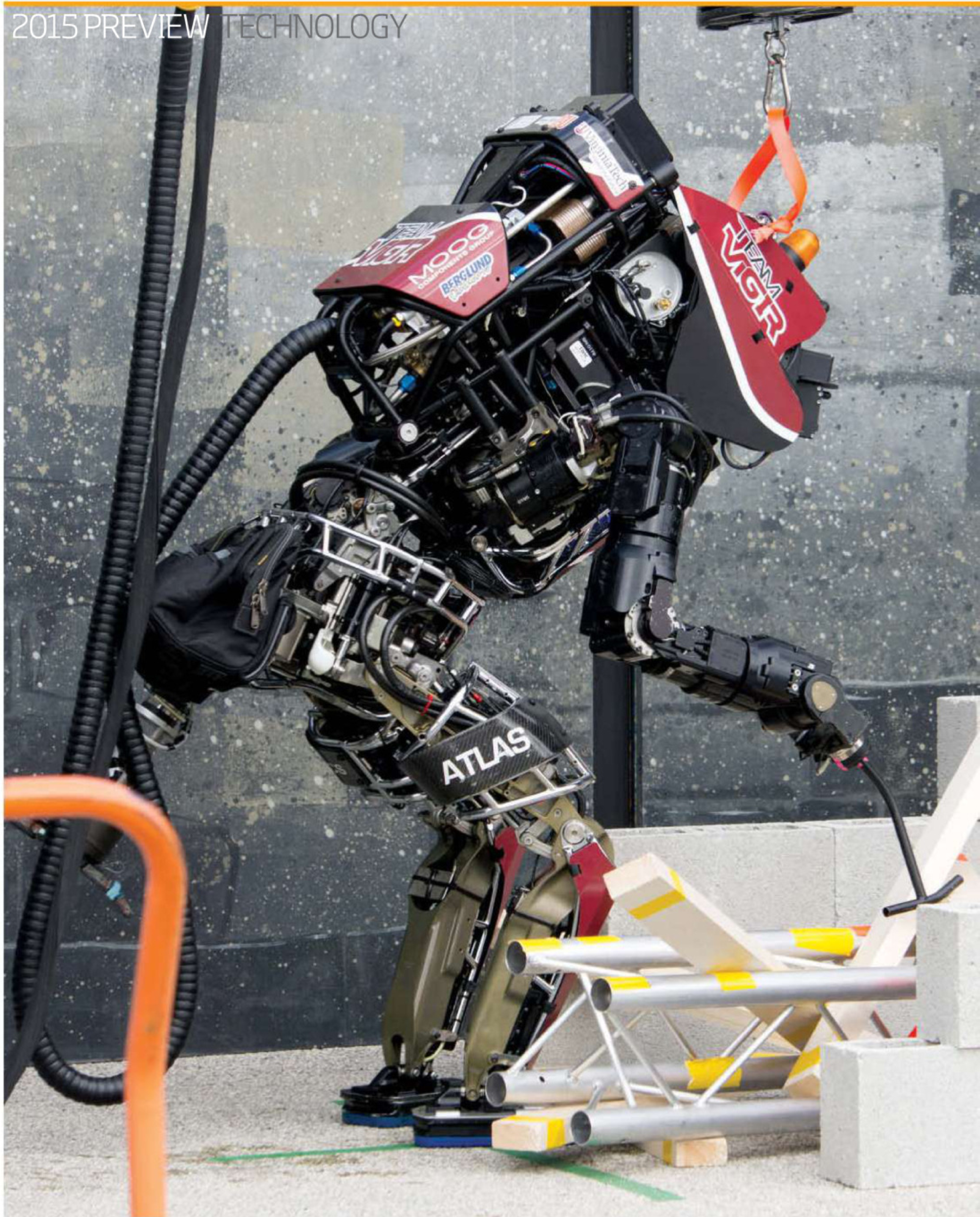
The human family acquired a few more relatives in 2013 and 2014, and next year we get to find out who they are.

Over 1500 bones belonging to a dozen individuals were discovered after a long, arduous descent into a deep South African cave in October 2013. It was a phenomenal find. No archaeological dig has ever yielded anything close to this. More than 100 people have been analysing the hoard to figure out who the bones belonged to. Expect a slew of announcements early next year.

What are the possibilities? The Rising Star cave, where the bones were found, is part of a large cave complex called the Cradle of Humankind. A number of skeletons previously found there are from between 2 and 3 million years ago, from a time when we think the *Homo* genus was splitting from *Australopithecus*. The most famous of the recent finds is a pair of near-complete skeletons discovered in 2008, belonging to *Australopithecus sediba*, an entirely new species.

A. sediba has a strange mix of human and australopithecine qualities. Some say that if the various bones had been found separately, they would have been assumed to belong to different species. That is exciting because it's a bit like seeing evolution in action.

If the Rising Star skeletons also turn out to look like chimeras with features from different species, that would further challenge attempts to draw a neat family tree with clearly defined common ancestors. Instead, it looks increasingly like a number of ape-like creatures existed a few million years back and interbred to produce a messy collection of species, from which we eventually emerged. Catherine Brahic





RESCUE BOTS GO HEAD-TO-HEAD

On 5 June, the final stage of the world's most important robotics competition will kick off in California. The DARPA Robotics Challenge will see 11 robots - like the one pictured from Team ViGIR - scramble over rubble, break down walls and clear debris to navigate a simulated disaster zone that would test most humans.

On display will be some of the most advanced technology: robotic limbs that can turn a water valve and robots that can climb ladders. It is the breeding ground for the machines of our future, because many of the skills that a robot needs in a disaster zone are the same ones they will use when working as cleaners and labourers in homes, offices and factories.

The idea behind DARPA's two-year challenge is to create robots that could have helped control the meltdown of the Fukushima Daiichi nuclear

"The challenge will see 11 robots scramble over rubble, break down walls and clear debris"

plant in Japan. Unlike humans, robots can safely enter plants with high radiation levels to attempt to turn on cooling systems.

Previous DARPA challenges have driven huge technological progress. Google's self-driving car emerged from a similar multi-year process called the Urban Challenge, in which competing teams quickly learned how to improve their cars by testing them in real-world scenarios. And it was the final year of the Urban Challenge that saw the biggest advances, with cars going from jerky navigation of a simple course to smooth driving at speed through a much more complex environment.

The same level of progress is expected for the robots. Even the winning robot at last year's challenge, designed by Schaft of Japan, moved excruciatingly slowly, taking minutes between each step up a ladder. It's hoped that June's event will see robots with smoother, speedier movement and a readiness for the real world that we have never seen before. Hal Hodson

PREPARE FOR TOTAL IMMERSION

Ready to be wowed? There are rumours that a consumer version of the virtual reality headset Oculus Rift will emerge sometime in 2015. And I intend to get one.

Oculus Rift started as the side project of Palmer Luckey in his parents' garage, funded largely by a Kickstarter campaign. The resulting device - black and blocky headgear - may look odd from the outside, but people have been amazed by the realistic experience they get on the inside.

Details of release remain murky. Insiders have discussed a possible date of mid-next year, perhaps in a restricted beta release similar to the one run by Google Glass. A headset is predicted to cost \$200 to \$400. Developers are already hard at work on a swathe of potential applications, including first-person shooter games, surgery training for students - even bespoke virtual reality films.

The headset may also open up some exciting opportunities for telepresence, transporting the wearer to a bustling city square or a school classroom halfway across the world. One team at Florida International University is using Oculus Rift to see through the eyes of a life-sized robot.

In March, Facebook acquired Oculus Rift for \$2 billion. The deal angered some early enthusiasts, who worry that Facebook will draw the focus away from gaming to advertising. However, the buyout may help make virtual reality more affordable for consumers.

No matter how people decide to use it, one thing is for sure: Oculus Rift has revived the long dormant dream of virtual reality for the masses. I have my fingers crossed that by this time next year, I will have stepped into the dream too. Aviva Rutkin

EBOLA FIGHT ON A KNIFE-EDGE

This was the year Ebola escaped its cage. The world is now trying to get it under control - but the response was late, and we don't yet know if we can. We may find out in 2015, as the epidemic peaks in West Africa.

In December 2013, the Ebola virus jumped from bats to people in West Africa for the first time, in Guinea. It then spread to Liberia and Sierra Leone. Not enough was done to stop it - mostly because of extreme local poverty - until cases numbered in the thousands and a global emergency was declared in August.

By September, the number of cases was rising exponentially. Massive efforts in recent weeks to isolate victims and limit transmission of the virus have prevented cases from soaring as predicted.

But Ebola could slip out of control again unless the all-out effort continues. In December, the World Health Organization had less than two-thirds of the funding it wants to last until

March. And so far it has tackled the easy part - cutting transmission in cities. Now the focus must move to the hinterlands, even though treatment centres built by rich countries in 2014 are mostly in towns. A broader effort and more funding will be needed in 2015 - even as cases dwindle and move out of range of TV crews.

And a traveller with the virus may unleash it in a country that cannot contain it. The WHO is trying to contain such an outbreak in Mali, and health experts fear how far the virus might spread if it reaches a country such as India.

On the bright side, tests of antiviral drugs and Ebola vaccines will start in early 2015 in the affected region. Vaccines may not be in time to stop this outbreak, but if they work, they could stop outbreaks elsewhere, and maybe prevent Ebola from becoming endemic in West Africa after this epidemic wanes. *Debora MacKenzie*

"The virus could slip out of control again unless the all-out effort continues"



NOW WE CAN SEE THE LIGHT

No, we're not going evangelical, just celebrating the fact that the New Year may well see the first trial of optogenetics in people.

Optogenetics is the process of inserting a light-responsive gene into cells that usually don't respond to light. A cell's behaviour can then be tweaked by switching the light on and off. It has been shown to work in mice and monkeys. Now a team at Gensight in Paris is gearing up for the first human trial, to treat blindness.

The plan is to sign up volunteers with retinitis pigmentosa - a type of inherited blindness caused by damage to the eye's light-responsive cells, or photoreceptors. Insert a gene into the cells that produce a light-responsive protein and hey presto, when light enters the eye, those photoreceptors should be switched on and pass information to all the cells in the eye and brain involved in vision.

It won't be as easy as all that, of course. It has worked on human eyeballs extracted after death, but it only gives black and white vision, and the revamped photoreceptors can't react to different light intensities. This means that they would become saturated and stop working when you walked from a darkness into light.

To overcome this, the team hopes to give volunteers glasses with a video camera attached, which would film the outside world and pass information to a mini projector that relays specific wavelengths of light to the eye at a set intensity.

To start, the team will only test the procedure in one eye of people who are blind, where there is no risk of damaging vision. The first safety trials should start towards the end of next year.

Helen Thomson

JUST THE RIGHT SIDE OF DEATH

What counts as death? Next year, the definition will be repeatedly tested as doctors place people with life-threatening injuries in suspended animation using a groundbreaking emergency technique.

Researchers at the UPMC Presbyterian Hospital in Pittsburgh, Pennsylvania, have developed the technique to give doctors more time to work on people's injuries. The body is cooled by rapidly replacing all the blood with cold saline. This stops almost all cellular activity and body temperature drops to 10 °C. At this point, the patient has no blood in their body, is not breathing and has no brain activity. In any other situation they would be declared clinically dead.

At this temperature, cells can survive without oxygen, instead slowly producing energy through anaerobic glycolysis. If your body attempted to do this now, as you sit there digesting your umpteenth festive lunch, you would survive for about 2 minutes. But at low temperatures, cells can survive in this state for hours. If doctors are able to fix the person's injuries in this time, they will be revived by slowly warming the body with blood. In animal experiments, this prompted the heart to start beating again of its own accord, but if that fails, patients will be manually resuscitated.

Doctors were awaiting their first patient last May – potentially someone with a stab or gunshot wound whose heart has stopped beating due to blood loss and who arrives at a time when the whole team is available. However, when I checked in with the lead doctor last month, he said he was no longer able to comment publicly on whether the procedure had been performed on anyone. My guess is that the study has already started and will carry on throughout 2015. It's certainly a macabre taste of what might be possible further down the line.

Helen Thomson

"The patient has no blood, isn't breathing and has no brain activity. In any other situation they'd be declared dead"



READY TO START BODY HACKING?

Right now I should be holding a vial of chlorophyll-derived eye drops that will boost my night vision. Unfortunately, there's a small problem. "I'm just making sure that I can get the amounts right and not scorch your eyes," writes Gabriel Licina, who runs a citizen science group called Science for the Masses and is acting as my supplier. "The papers we have access to are very specific in some regards and very vague in others." Welcome to the dicey world of biohacking, where hobbyists try to improve their own bodies.

Smart watches will be big next year, and as personal devices become more intimate, there will be increasing interest in tracking personal biometrics and health. But why just monitor your body when you could modify it for the better?

Biohacking is still a niche field, but the possibilities are growing. The most successful innovations so far are small magnets that can be implanted in your fingertips, allowing you to feel electric fields. Also popular are RFID chips similar to those used to tag pets, which can be implanted under the skin and used as remote keys, wallets and data storage devices.

More esoteric experiments include internal compasses that vibrate when you face north, diets that trigger near-infrared vision, and my own effort, tuning hearing to Wi-Fi fields.

However, anyone expecting to become a superhero overnight will probably be disappointed. Humans - messy, complex, occasionally fragile, legally protected - make poor testbeds for new technology. Nowhere is this need for caution more keenly felt than when pouring experimental chlorophyll extract into your own eyes. Frank Swain

STORY OF THE YEAR COMET LANDING



Philae landed on a comet
that from some angles
looks like a rubber duck

ESA/ROSETTA/NAVCAM

SPACE & PHYSICS

THE PHILAE LANDING

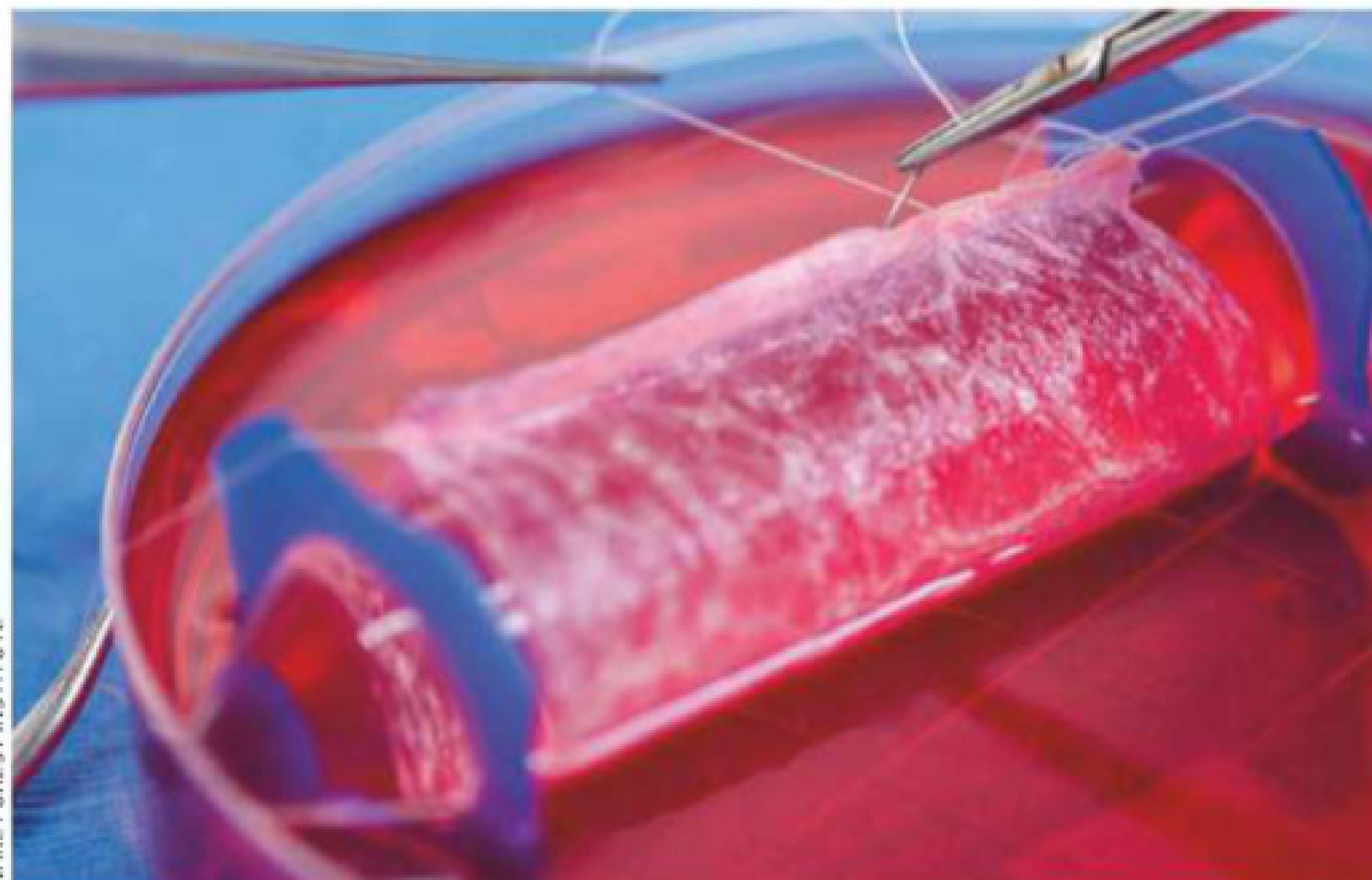
"We are there and Philae is talking to us. We are on the comet!" These words marked the high point of the European Space Agency's Rosetta mission, which arrived at comet 67P/Churyumov-Gerasimenko after a decade-long journey. Besides the dramatic touchdown of Philae in November, Rosetta's tense wake-up in January and the close-up photos of the comet in August meant the mission made headlines all year.

EARTH'S BACKUP

Think of Earth as a giant supercomputer, with the moon as our backup hard drive. That's the vision behind plans announced in May to use the moon as off-planet storage for the religious, cultural and genetic trappings of humanity. Sending a sacred Jewish scroll to the moon could be just the beginning of an apocalypse-proof backup of all culture and life on Earth.

HOW IT ALL BEGAN

The universe was born in an unimaginably fast expansion, and we have proof! And then we didn't. In March we seemed to have evidence for inflation - the dizzying growth of the universe after the big bang - but the results were soon thrown into doubt. We'll have to wait to see what the space-based Planck telescope can tell us - its results are due in early 2015.



HEALTH

ULTIMATE REJUVENATION

It's like the dark plot of a vampire movie. Starting in October, people with Alzheimer's disease in California were given transfusions of young blood to see if it improves their cognition. Young mouse blood has been shown to improve the brain power and health of older mice and could even make them look younger. If it works in humans, the implications could be huge, not least for big pharma. Watch this space.

MASTER ON-OFF SWITCH

One moment you're conscious, the next you're not. For the first time, researchers switched off consciousness by electrically stimulating a single part of the brain. The discovery, reported in June, suggests that the area - the claustrum - might be integral to combining disparate brain activity into a seamless package of thoughts, sensations and emotions.

LAB-GROWN VAGINA

"It was incredible how my body accepted it. Now it works as if it were not made in a lab =)." So said a Mexican woman who was one of the first to receive a lab-grown vagina made from her own cells (see below). After six months, the women could menstruate and have sex, and should now be able to have children. The surgeon behind the breakthrough is now developing lab-grown penises.



GEORGIA TECH

TECHNOLOGY

CYBORG DRUMMER

Jason Barnes had wanted to be a drummer since he was a teenager. When he lost his arm he thought his dream was over. Now he has a second chance, thanks to a robotic arm (see above) that should allow him to play just as well as anyone - or perhaps better. He played his first concert with the prosthesis in March.

FIRST FAMILY ROBOT

It doesn't just recognise you, it can field your phone calls and chat to you at dinner. Jibo, unveiled in July, is the first robot designed to be used by the whole family and will be available to buy in 2015.

BITCOIN REVOLUTION

It has been called many things, from the future of money to a drug dealer's dream. But beyond being the web's first native currency, it became clear this year that Bitcoin's true innovation is its underlying technology, the "block chain". That concept is being used to transform Bitcoin - and money online.

THE SOUND OF WI-FI

"I can hear birds tweeting in the trees, traffic prowling the back roads, children playing in gardens and Wi-Fi leaching from their homes." We met the man who has hacked his hearing so he can listen in to the data that surrounds us.

LIVING PLANET

ELECTRIC LIFE FORMS

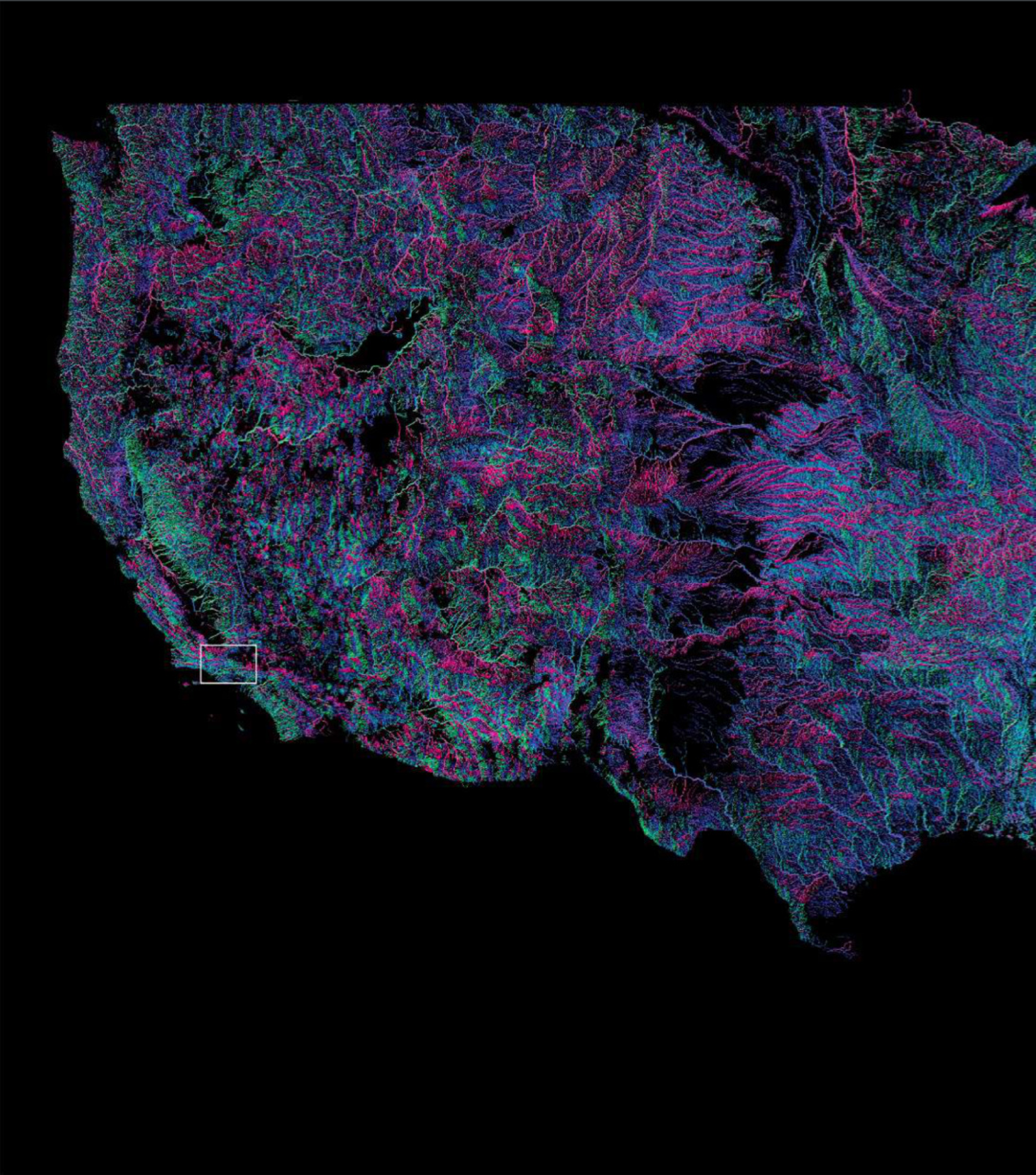
Bacteria can survive on a variety of energy sources, but living on electricity is particularly weird. Think of Frankenstein's monster, brought to life by galvanic energy, except "electric bacteria" turn out to be very real, and this year they started popping up all over the place. Unlike any other life on Earth, these extraordinary microbes use energy in its purest form - they eat and breathe electrons harvested from rocks and metals.

THE FIRST AMERICAN

A boy who died 12,600 years ago had his genome sequenced, it was announced in February. We may never know who the Anzick child was, why he died aged 3 in the foothills of the American Rockies or why he was buried beneath a cache of flints. But incredibly, his family turns out to be the direct ancestors of most tribes in Central and South America - and probably the US too.

WATER WORLD

How did we miss it? In June, we found out that a reservoir of water three times the volume of all the oceans sits deep beneath Earth's surface. It is hidden in a blue rock called ringwoodite that lies 700 kilometres beneath our feet, in the hot rock of the mantle between us and Earth's core. It could help explain where Earth's seas came from.





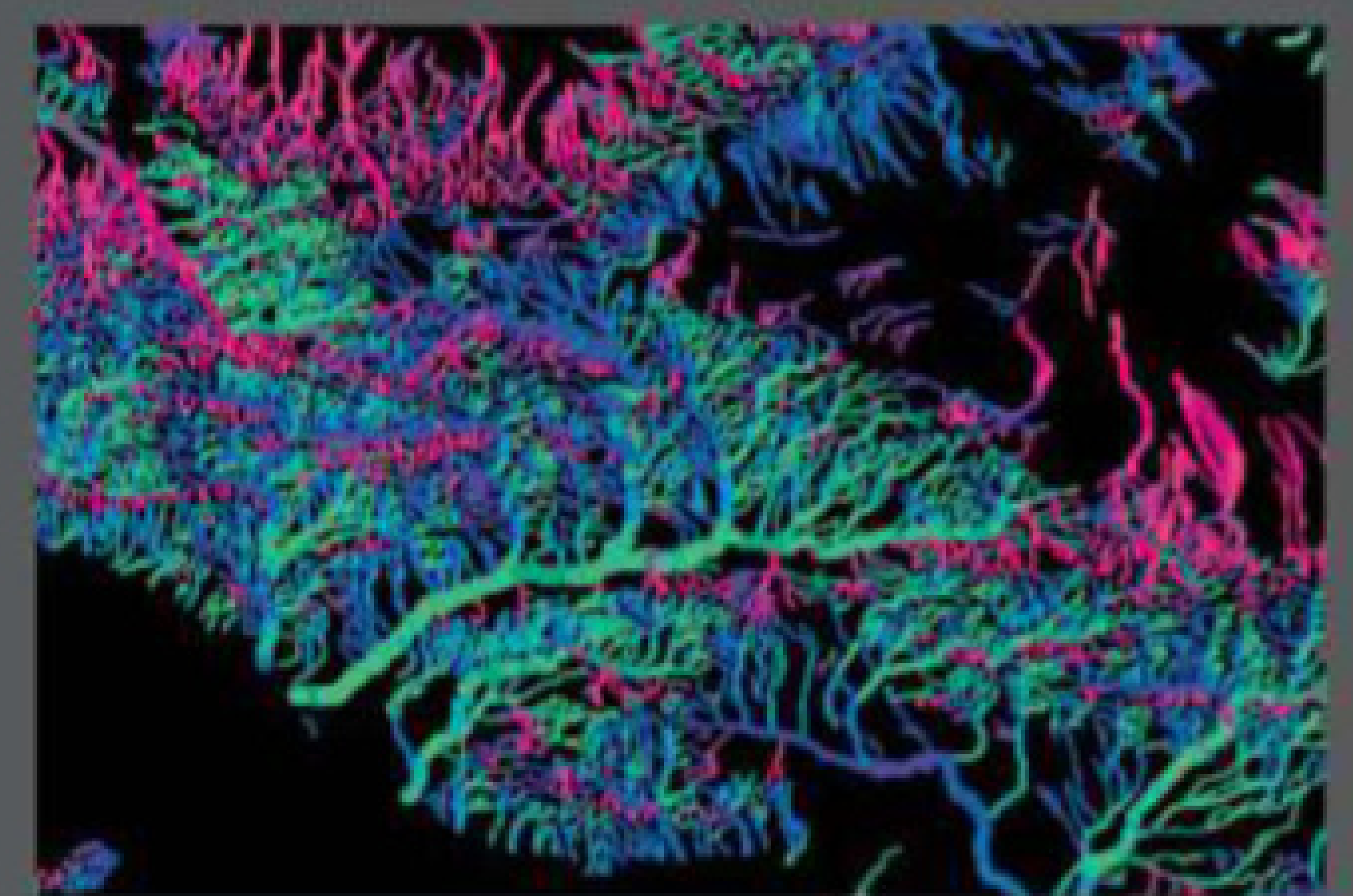
Go with the flow

TWO hundred and fifty thousand rivers run through it. Usually when we run photos like this they depict the wiring of the brain, but this, while bigger in absolute terms and smaller in complexity, is no less beautiful: it shows all the rivers in the US, coloured according to direction of flow.

Andrew Hill of data-visualisation outfit Vizzuality used the CartoDB platform and the National Hydrography Dataset, put out by the US Geological Survey, to create this amazing map. He says it was actually quite quick to make (for details, see bit.ly/WaterMaps). If you think it looks cool in print, you should see it online: bit.ly/Riverflow.

"There are 18 distinct colours around the compass," says Hill. True pink, for example, represents a river that runs north-south or south-north. When zoomed far out, as in the main image, the colours tend to blend in. But as you zoom in, pinks, blues, greens and reds jump out at you, as seen in the inset photo below, of the region just north of Los Angeles.

The longest river on the map is the Missouri at 4088 kilometres. But the biggest in terms of water volume is the Mississippi, which is deeper. At 1114 kilometres, the Yellowstone is the longest un-dammed river in the US, while the Rio Grande, flowing into the Gulf of Mexico, is the only one featuring in a Duran Duran song. Rowan Hooper



Image

Andrew Hill USGS

Larger than life

A staggering number of people believe in outlandish conspiracy theories. How should we respond, ask **Eric Oliver** and **Tom Wood**

THE world is awash with conspiracy theories: Malaysia Airlines flight 17 was diverted by the CIA; drug companies are preventing the release of natural cures for cancer; Queen Elizabeth is part of a secret plot to control the world.

Most pundits dismiss such theories as the ravings of a paranoid fringe. Some claim they are cranks who pose a serious risk to society. The evidence, however, reveals a more nuanced picture.

For the past eight years, we have been asking people in the US their views about conspiracy theories. We find three important facts.

First, the theories are widely endorsed. At any given time, at least half of Americans agree with one or more of the common ones.

Second, adherence is common across the population. Although racial minorities and the less-educated embrace them more



readily, educated whites also subscribe to them.

Third, conspiracy theories are embraced across the ideological spectrum. More conservatives than liberals believe that Barack Obama fabricated his birth certificate, but plenty of liberals believe 9/11 was an inside job. Some conspiracies are equally appealing to the left and right.

As researchers, the interesting question to us is not whether these theories are right or wrong, but why so many people endorse them in the face of overwhelming evidence. We think the answer lies in human psychology.

The brain did not evolve to process information about industrial economies, terrorism or medicine, but about survival in the wild. This includes a tendency to assume that unseen predators are lurking or that coincidental events are somehow related.

A gift from above

Fancy christening an alien world? Keep ideas on a tight leash, advises **Heather Couper**

WHAT'S in a name? A chance of cosmic immortality, if you get it right. The International Astronomical Union (IAU) is asking "public and astronomy-interested organisations" to officially name 305 planets orbiting other stars in our galaxy.

While pondering ideas, history offers us a few lessons. Flash back

to 1781: musician and amateur astronomer William Herschel was peering through a telescope in his garden in Bath, UK, when he spotted a curious object "either nebulous star, or perhaps a comet". It turned out Herschel's discovery was rather more significant – it was a new planet.

But what to call it? Herschel

named it after the ruling King George III, one of the few British monarchs to have a deep interest in science. But he was swiftly overruled by the astronomical community. Planets had been traditionally named after mythological deities. Imagine: Mercury, Venus, Earth, Mars, Jupiter, Saturn, George, Neptune... it doesn't bear thinking about. Uranus – in mythology the father of Saturn – won. Sorry, George.

By the start of the 19th century,

"Asteroid 2309 is named Mr Spock, not after the *Star Trek* character but the discoverer's cat"

astronomers were uncovering dozens of asteroids and minor planets in the belt between Mars and Jupiter. For a while, tradition held – Ceres, Vesta, Pallas – but as the asteroid count grew, the myths ran out. They started calling the cosmic runts after mistresses and pets. Asteroid 2309 is named Mr Spock, not after the *Star Trek* character but the discoverer's cat. Horrified, the IAU banned names of pets and mistresses.

But strict rules still leave room for creative manoeuvres. In 1978, astronomer Jim Christy discovered a moon orbiting Pluto. His instinct was to name it after his wife Charlene (nicknamed Shar).

Conspiracy theories reflect how we intuitively understand our world and, ironically, provide emotional reassurance. They are stories with good and bad guys, conflict, resolution and other narrative elements that have a natural appeal. In short, to adherents, conspiracy theories feel like the truth.

It is this that makes them problematic. By crystallising intuitions into incontrovertible claims, they limit possibilities for public discourse. This might not be a problem if the conspiracy involves aliens. But when it comes to important issues such as gun control or vaccinations, conspiracy theories impede our ability to sustain public debate.

Thus, rather than trying to argue or reason, the first step should be to empathise. After all, whether knocking on wood or wishing someone luck, we all engage in magical thinking. Only by appreciating the emotional tug of conspiracy theories will it be possible for us to communicate in a meaningful way with our neighbours in tinfoil hats. ■

Eric Oliver is a political scientist at the University of Chicago. Tom Wood is a political scientist at Ohio State University in Columbus. Their latest findings are in *JAMA* (vol 174, p 817)

But mythology had to prevail. He chose Charon (“Shar-on” in some astronomer circles), the ferryman who transported souls across the river Styx to Pluto’s underworld.

Now groups keen on astronomy – clubs, planetariums, schools – have a chance to join the name game and christen a new world. The rules: 16 characters or fewer; inoffensive; pronounceable (in some language); and no names of living individuals or pets!

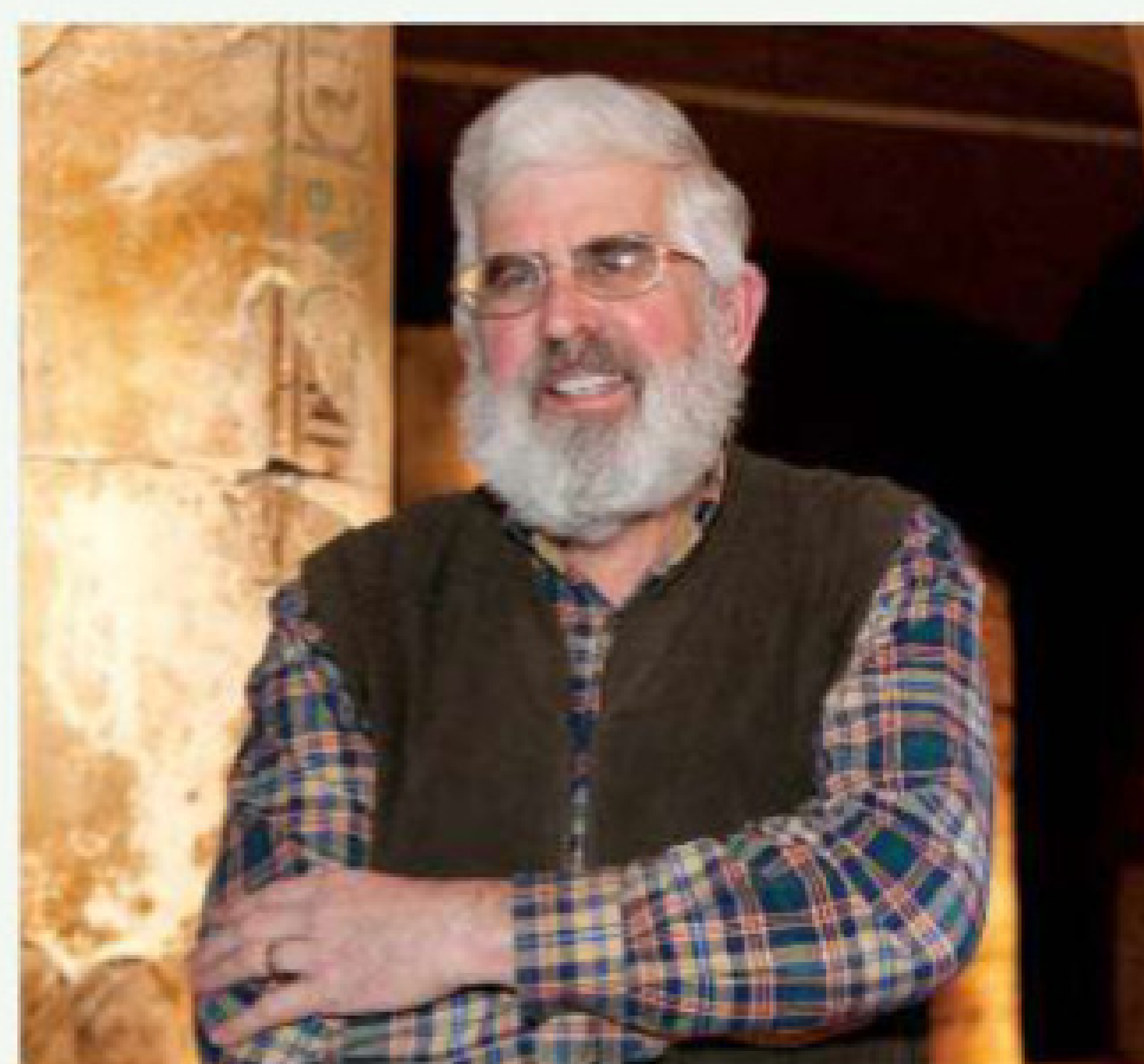
Good luck. It’s a real gift of a chance. Just don’t suggest Fido. ■

Heather Couper is a UK astronomer and science populariser. Asteroid 3922 was named Heather after her in 1999

ONE MINUTE INTERVIEW

Beverage with heritage

Recreating ancient ales and wines is a subtle alchemy, but **Patrick McGovern** knows all the tricks



PROFILE

Patrick McGovern directs the Biomolecular Archaeology Project for Cuisine, Fermented Beverages and Health, at the University of Pennsylvania Museum. Many of his ancient brews are sold by Dogfish Head brewery in Delaware

How did you start making ancient drinks?

One of the first we made was the Midas beverage, based on residues in bronze vessels recovered from the Midas tomb in Turkey, which dates from 700 BC. These pointed to an unusual drink combining wine, barley beer and mead. There were also food remains in the tomb that suggested a barbecued lamb or goat stew with lentils and spices. We tried to recreate the funerary feast as a way of bringing the past to life.

How do you go about recreating a drink?

People give me either samples of pottery or residues from ancient vessels possibly used for making, storing or drinking a fermented beverage. I identify the markers of specific natural products: tartaric acid is a fingerprint compound for grapes in the Middle East, for example, while calcium oxalate points to the presence of barley beer.

What did the Midas beverage taste like?

We knew the three basic components – grapes, barley and honey – but we didn’t know what the

bittering agent was. It couldn’t be hops, as they only became available in Europe around AD 700, so we looked at the eastern Mediterranean spices that would have been available: saffron, cardamom, bitter vetch, cumin. In a competition among microbreweries to recreate the beverage, Delaware-based Dogfish Head used the best-quality saffron as their bittering agent, as well as Greek honey made from thyme blossom. Their winning beverage was on the sweet side, but the saffron gave it aromatic properties.

How does ancient booze compare with the modern stuff?

Ancient beverages tended to be much more multidimensional. People didn’t necessarily specialise in one beverage; the wine industry was inseparable from the beer and mead industry in the earliest periods. Also, they wanted to be sure they had enough sugar to get the fermentation going, so they took whatever they had that contained sugar and mixed them together.

Which of your recreations would you pair with a traditional turkey roast?

The turkey is an American bird, so I’d propose having your English Christmas dinner with our American ancient ale, Theobroma, which was recreated by chemical analysis of pottery fragments from Honduras, dated to 1400 BC. Its cacao aroma will go nicely with the bird, a bit like a chocolate mole over chicken – a Mexican favourite.

What about for a beach barbecue?

If you were barbecuing fish or shrimp, I’d go for Midas Touch. It’s a little like white wine, and it has delicious, piquant qualities which I think would go well with fish. For barbecued steak, I’d go for our early Etruscan ale, Etrusca, whose recreation is based on evidence from 2800-year-old tombs in central Italy. Its backbone is malted heirloom barley and wheat, but it also has hazelnut flour and pomegranate, which would be a good match for the beef. It even contains myrrh, for an added Christmas motif.

Interview by Linda Geddes

This will make you yawn

We all do it, but why? Neuroscientist **Simon Thompson** unravels the mystery of yawning

WHEN I give talks about my work, I know that before too long the audience will start to yawn. Just thinking about yawning makes us do it, but the mechanisms behind this everyday behaviour are a mystery.

Yawning is often the first thing we do when we wake up, but we also do it when we are bored, tired or anxious. It is a primitive reflex that we share with other animals, from fish to mammals. We first start yawning in the womb, at around 20 weeks gestation, and as we age, we yawn less frequently. It happens most

“Patients were able to raise their paralysed arm when they yawned”

in the morning, but despite yawning being universal, the reason we do it is still unclear.

Boredom leads to yawning, so it has long been assumed that the action is an arousal reflex that makes us feel more awake by stretching the muscles surrounding the lungs, or by bringing more oxygen to the blood and the brain. Yet in tests, breathing air with elevated carbon dioxide levels or even pure oxygen made no difference to the frequency of yawns.

Another theory, proposed by the French physician Olivier Walusinski, is that yawning improves the circulation of the fluid surrounding the brain, which switches on our attentional systems and helps us focus on a task. This might explain why parachutists are encouraged to yawn before they leap, and why elite athletes often yawn naturally before they compete.

But the strangest aspect of yawning is its infectiousness. When we see another person – or even an animal – yawn, it makes us do it too. How can we make sense of these different types of yawning?

In 2007 a new perspective emerged: yawning is a mechanism to cool the brain. Experiments lead by Gordon Gallup at the University at Albany, State University of New York, showed that people yawned far less when their head was cooled by a cold pack, compared with if they held a heated pack to their forehead. In fact, this view is not so new. In 400 BC, Hippocrates wrote about yawning in his *Treatise on Wind*, “...the accumulated air in the body, like steam escaping from hot cauldrons is violently expelled when the body temperature rises”.

The temperature of the brain rises when we are fatigued, so it is possible that yawning is a mechanism to protect the brain from overheating due to tiredness. This fits with my observations of people with multiple sclerosis (MS), who often yawn a great deal when they are fatigued. Common symptoms of MS, a disease in which the body’s immune system attacks the myelin sheath that coats nerve cells, are fatigue and rises in brain temperature. Yawning, fatigue and rises in brain temperature appear to be linked. How?

Temperature regulation is controlled by a brain region called the hypothalamus, and this is intimately linked to two other structures: the pituitary gland – also in the brain – and the adrenal glands, which secrete adrenaline as well as the hormone cortisol. This is produced in response to stress and is important for increasing alertness.



HULTON ARCHIVE/GETTY

Yawning is a primitive reflex that we share with other creatures

My research has revealed that blood cortisol levels rise when we yawn, and I suspect that it is the rise in cortisol that triggers a yawn (*Medical Hypotheses*, vol 83, p 494). Yawning seems to raise cortisol levels further, and in doing so protects the body by stimulating the production of adrenaline to make us more alert. It also triggers the



hypothalamus to cool down the brain. This might also explain why we yawn when we are anxious, as we often start to sweat and our brains possibly become slightly hotter – though this idea has not been tested.

I came to work on yawning through a different avenue of research. I was fascinated by an observation I made that the temperature at the top of your head makes a difference to the way you feel after exercise. For example, if your head is hotter, you are more likely to

feel tired. This led me to investigate fatigue, and in particular why it makes us yawn. Maybe the hormones that underlie the natural response to stress and fatigue were also responsible for yawning?

I am currently exploring the link between cortisol levels, yawning and fatigue in conjunction with a team of neuroscientists at various French universities. We are investigating whether the frequent yawning by people with MS is indeed a protective

PROFILE

Simon Thompson is a clinical psychologist and neuroscientist at Bournemouth University, UK, and editor of *Psychology of Trauma: Clinical Reviews, Case Histories, Research*

response, using fMRI brain scanning and cortisol testing. We think that excessive yawning and abnormally high cortisol levels may even be early warning signs of MS.

Other neurological conditions can give us clues about yawning. For example, in 1923 the British neurologist Francis Walshe found that patients who were paralysed as a result of lesions in the brainstem region could raise their arm when they yawned. The yawn somehow overruled the paralysis. This ability is also seen in people who have had a stroke, and indicates that the trigger site of the yawn might be in the brainstem. I plan to investigate yawning in other conditions, such as Parkinson's disease, too.

Infectious yawning

How does contagious yawning fit into this picture? None of these observations explain it. It's possible that contagious yawning is something different, and might instead have a social purpose. Steven Palek and his colleagues at the University at Albany propose that contagious yawning is part of a more general phenomenon to do with the ability to infer the mental states of others. They found that people's susceptibility to contagious yawning is linked to their ability to infer or empathise with what others want or intend to do, and that seeing another person yawn taps into the part of our brain responsible for self-awareness.

The response is especially strong with members of our own group, and is influenced by other social factors. For example, chimpanzees are more likely to yawn when they see a dominant male do it, compared with a female. And the likelihood of someone "catching" a yawn depends on their ability to perceive facial expressions – hence people with autism tend to be less affected – according to research by Atsushi Senju, now at Birkbeck, University of London.

I suspect that the social drivers of yawning can override the physiological ones, so that we yawn when others do irrespective of the more "primitive" drivers such as brain temperature or cortisol levels.

This simple act turns out to be surprisingly complex. Have I made you yawn yet? ■

QI's little helpers

Digging up fascinating and unlikely facts is all in a day's work for Stephen Fry's team of elves. *New Scientist* visited their workshop

Tell us a bit about your TV programme, *QI*

James Harkin: It's based on the idea that everything is interesting if you look at it in the right way. We find interesting things then ask comedians to answer impossible questions about them.

How did the show first come to be made?

James: The story goes that when John Lloyd [the show's creator] had kids, he realised that he didn't know the first thing about anything. So he started reading encyclopaedias. He decided to make an encyclopaedia without the dull bits.

Anna Ptaszynski: His son Harry was a massive inspiration. When he was 4 or 5 he would ask John weird questions: Why are we here? What is the sun? It made John realise that, as soon as we finish formal education, we suddenly stop asking those kinds of questions. I suppose that's what we are trying to do.

Your job is to research the questions, so why are you known as "elves"?

James: I think we got our name from Stephen Fry, the host, who is a fan of Tolkien. He had to reference us in the first series and off the top of his head called us elves. So we ran with it.

How do you get to become an elf?

Anna: It's unorthodox. James has the best story. James: I studied maths and physics at uni, and was working as an accountant. I was doing my work quickly so I had a lot of time to spend on the internet. I found the QI talk forums where they come up with questions and got involved. Luckily enough, they grabbed me and dragged me to London and gave me a job.

So why aren't you a mathematician or physicist?

James: Not good enough.
Andrew Hunter Murray: Anybody can do degree-level maths, but finding interesting facts...

That's a specialist skill.

James: I think that's kind of it. When I studied maths, for instance, the thing that I enjoyed most was the history.

But then you became an accountant...

James: I needed to pay the bills.

Before you worked for *QI*, did you all have magpie-like minds, always collecting facts and esoteric ideas?

Anne Miller: Yes. We're the ones in the pub who go, "The funny thing about cheese, guys..." And everyone rolls their eyes.

Andrew: The writer Neil Gaiman says that writers have the same number of ideas as other people but just happen to write them down. I think we probably come into contact with the same number of interesting facts as other people, but we are always collecting them.

What makes a good *QI* fact?

Andrew: What we're looking for is the unexpected thing that makes you want to tell other people. The key element is that you immediately want to communicate it.

James: Unless someone puts you on the spot. Then you can't think of anything.

Andrew: I've always got mine at the ready: kangaroos have three vaginas.

Anne: Mine is that a baby puffin is called a puffling. That's my favourite fact.

PROFILE

The QI Elves are the researchers for *QI* (*Quite Interesting*), a BBC comedy panel show hosted by Stephen Fry in which guests attempt to answer weird and wonderful questions based on facts gathered by the team. Their ranks include (from left to right) Anne Miller, James Harkin, Anna Ptaszynski and Andrew Hunter Murray



James: Every day you find something and think "that is amazing, must keep that, it will come in useful one day".

When you find a fact that you want to keep, what do you do?

Anne: You store it.

Anna: You keep it safe.

Andrew: But it isn't always clear where it should go – every fact has several branches off it, and if you follow one, you can suddenly end up in different territory and find this whole chain of interesting things along the way.

You also do a podcast called *No Such Thing as a Fish* where you discuss favourite facts with what sounds like incredible knowledge.

Andrew: We take each other's facts away and do our homework on them. So when we come back to do the podcast we all have something.

Photographed for New Scientist by Marc Schlossman



The impression is that you just know loads of stuff off the cuff.

Andrew: Yes, forget what I said – we know it all.

How carefully do you check your facts?

Anna: We're as careful as we can be. But we still get emails from people.

James: Facts are always changing and there's not much we can do about that. But we try and get a couple of sources on every fact we put in. Of course, everyone makes mistakes.

What is your biggest howler?

Anna: There is one that we thought was true – and I still think maybe you'll find evidence that it is – that the government owns 100,000 cats in order to catch the mice in various public buildings. It's an oft-repeated thing. It's been in the newspapers. But it is very hard to verify.

James: Another is that we said poodle grooming was an Olympic sport in Paris in 1900. It turns out we fell for an April Fool in *The Daily Telegraph*.

Anna: Remember, we are looking for facts that seem like they're not true.

What is your favourite science fact?

James: Mine is generally whatever I've heard recently. I read in *New Scientist* that the corona of the sun is hotter than the centre, and no one can work out why. It rains plasma on there as well. I think it's fascinating that something so basic has so many mysteries.

Anna: Mine is that baby elephants have to be taught to use their trunks. That tickles me.

James: An elephant's sense of smell is so good that they can tell the difference between two tribes.

Andrew: They can also differentiate between

human languages. They react with fear to adult male voices from tribes that hunt elephants but are not bothered by voices from tribes that don't. Also, an elephant has more muscles in its trunk than a human has in their entire body.

Is there a serious purpose to all of this?

Andrew: We think there is, although it can sound a bit pretentious to talk about it.

Talk about it anyway.

Anna: I think it's about finding out more about the world and making people feel a bit better along the way. The one thing I love about *QI* is that you can be stupid. You can say "I don't know". We all have different knowledge and we like to share it.

Anna: It is basically a funny TV show, but we would love *QI* to have a bigger effect. In school, you start with the basic stuff and memorise it. But think if you instead started with the weird and quirky stuff that piques your interest, and then learned how it works and why. I would love it if people were learning more like that.

Andrew: We often try to remind ourselves that

"We're the ones in the pub who go, 'The funny thing about cheese...'"

the fourth basic urge, after food, sex and shelter, is curiosity. We bridle a bit at being called trivia because there's nothing trivial about finding out more about the world, whether it's atomic structures or hairdressers in North Korea.

If you weren't elves, what would you do?

Anna: I recently got a really strong urge to be an anthropologist. I think it would be really great to go around the world and meet people who are unbelievably different.

James: I thought that I would like to be a writer and genuinely thought I would like to write for *New Scientist*. Maybe one day.

Do your family and friends enjoy your endless curiosity?

Andrew: They are deeply ashamed.

Anna: It depends. Sometimes my friends get hacked off with the constant facts in the middle of conversations.

James: I think my friends just put up with it as a personality quirk.

Anna: Like an illness. ■

Interview by Graham Lawton and Tiffany O'Callaghan. See page 89 for the *QI* Elves quiz

State of violence

From Robert Stepan

Alan Page Fiske and Tage Shakti Rai argue that most violence arises from morality, not a lack of it (29 November, p 30).

But they omit to say anything about state violence, which is also often driven by ostensibly moral reasons. The moral justifications for state violence are usually concocted with great efforts expended to sell the fiction.

I wonder if the authors have considered whether the individual's moral justifications for violence might arise similarly? Recent work has demonstrated the brain's ability to rationalise almost anything, and without any conscious awareness of the wild mental gymnastics involved.

Canyon Lake, Texas, US

Machine martyrs

From Robbie Walker

Chris Baraniuk addresses the use of robots in armed conflict not only from a technical point of view, as he also considers the ethical, political and social consequences (15 November, p 38).

Unfortunately he doesn't give greater consideration to what happens when combatants ignore international conventions. Here issues of terrorism or genocide become central.

We move from technical fail-safe systems and the requirement for a human to make an ethical decision before issuing that "kill order", to autonomous suicide bombers or indiscriminate attacks on civilians. A robot suicide bomber cannot become a holy martyr, but I doubt that will stop someone trying to build one.

London, UK

Costing the Earth

From Andy Taylor

I read with interest Josh Tetrick's plans for creating eco-friendly

mayonnaise by substituting pea protein for eggs (22 November, p 31).

Whilst agreeing with his statement that "the vast majority of food we buy today is bad for our bodies and destructive for the planet", I feel that his product is rather missing the point.

Mayonnaise is not a staple food, it is a luxury item that has been turned into a staple food through industrial production methods.

Mayonnaise treated as a luxury item is bad neither for humans, chickens nor the environment. The real goal should be a re-evaluation of the way we produce and consume food, not simply finding new ways of carrying on as before.

Tetrick's aims are laudable but he does not say how much land would be required to produce his plant mayonnaise, land that could perhaps be better used for developing products that really would deliver positive change.

Edinburgh, UK

Data freeze



From Stephen Jewson

Bravo to the physicists at CERN for making their data freely available online (29 November, p 6). Can we hope that climate scientists will be inspired to follow suit?

One might think that helping solve the world's climate problems is a more pressing issue than finding new types of boson, but basic observational data on the

world's climate is still frustratingly difficult and expensive to get hold of.

Many countries can be criticised, but the UK is one of the worst offenders, where climate data access and use is restricted by Crown copyright, and the Met Office has a team dedicated to trying to sell information on the climate.

London, UK

Out of the fire

From Guy Cox

Perry Bebbington makes a very important point in his letter when he says that oil used to make plastics should be referred to as "plastic ore" rather than fossil fuel (29 November, p 32).

But he doesn't take this line of thought far enough. Can you imagine modern civilisation without plastics or steel? Plastics need petroleum – although other alternatives may be developed – and steel production needs coal, for which no potential alternatives are in sight.

How irresponsible is it to burn these precious resources for energy when alternative energy sources are available.

Sydney, Australia

Carbon's sting

From Robert Gibbs

Arguing against divestment from fossil fuels, Paul Younger suggests we should exploit the access that investing in fuel companies gives us to company leaders (15 November, p 26).

I would suggest rather that we remind ourselves of the story of the frog that agrees to ferry a scorpion across a river. Midway, the scorpion stings the frog, dooming both to drown. When the frog asks why, the scorpion replies: "because I am a scorpion".

Trading investments to get close to fuel companies will end the same way. Of course, we will

all be boiling alive rather than drowning. We must learn to use less and share more equitably and take back control of our planet.

Glasgow, UK

Propeller heads

From George Cowin

Owen Mooney makes good points about the need for fossil fuels as part of an effective energy portfolio (22 November, p 34).

I would add that we have the technologies to make dirty coal



clean. Most energy plants are single-pass processes and at best 30 per cent efficient. Waste energy is discharged into the atmosphere.

Why not capture most of the waste heat generated and use it in second and third-pass processes that add to the efficiency of coal? We have the technology to do this but the power companies do not have the incentive.

Then there are the exhaust gases. Again we have the biological technologies to utilise these to create usable products. Once they are cooled by the added processes in the plant, they would be usable for other technologies.

With photosynthesis we can create fuel oils, plastics, fertilisers and more. We do not need to discharge it into the atmosphere.

I hear you say "it is not economical!" Well, when Earth's atmosphere is loaded with carbon dioxide, will you still be saying that? It is our responsibility as a

community to clean up our use of fossil fuels and leave the world cleaner for our children.

Brisbane, Australia

From Terence Hollingworth

Owen Mooney writes that if the aviation industry had advanced as little as the nuclear industry, “we would still be flying propeller aircraft”. We are.

The ATR 42 and ATR 72 aircraft built in Toulouse have been experiencing a resurgence of interest in recent years. Over their operating range of about 1500 kilometres, the difference in flight time between these and fan jet aircraft is of little importance, but the much better fuel economy of propeller-driven aircraft gives them a clear advantage.

He might also note that in the UK, the Royal Air Force has started to take delivery of Airbus A400 military transport aircraft, these are also propeller driven.

Blagnac, France

Code monkeys

From Henry Lynam

The screenshot illustrating your story on computers that can program themselves (1 November, p 21) shows PHP code in which the main method begins with an instruction to print the word “banana”, followed immediately by an “exit” clause, which makes the rest of the code redundant.

Have the programmers already been replaced by a roomful of monkeys with web access?

Dublin, Ireland

Cloud control

From Marc Smith-Evans

Andy Coghlan examines a number of geoengineering proposals that could be applied as panaceas for the global indecisiveness around climate change (29 November, p 8).

All of those included seem a long way from being realised as

viable projects, and some could have serious side effects, notwithstanding the impact of failure and lost time.

But who chooses and who takes responsibility for such projects? The United Nations is light years away from being in this position.

There is another solution – reducing carbon emissions – but that is tragically beyond the grasp of bickering primates.

Jeddah, Saudi Arabia

First in class

From Graham Thomas

Your article by Aviva Rutkin highlighted the marked difference between the language of children from poor and more affluent backgrounds (29 November, p 14).

This difference was identified in landmark research by Basil Bernstein at the University of London’s Institute of Education more than half a century ago.

He characterised the language of working-class children as “limited code” and that of middle-class children as “elaborated code”. A 10-year study of interactions between mothers and children from the two social backgrounds was subsequently led by his sometime colleague Ruqaiya Hasan, later of Macquarie University in Australia.

St Albans, Hertfordshire, UK

Deadly dessert

From Peter Urban

Regarding your special report on chemical additives, “pesticides” is not a chemically meaningful classification (29 November, p 34).

Since the natural world is the battleground for chemical warfare fought constantly between species, it is filled with pesticides.

Many of the pesticides we exploit are natural in origin, such as antibiotics, strychnine and nicotine. At this time of year, let us consider the cyanide in our



Christmas cake. Synthetic cyanide is sometimes used as a crop fumigant, but that is not how it finds its way into our food.

Many plants produce cyanide, probably as a larvicide. The plum family does, for example, which includes the almond and cherry.

Traditional marzipan includes poisonous bitter almonds in the recipe. I also fancy I have tasted cyanide in parsnips, another seasonal favourite.

Kenilworth, Warwickshire, UK

Radioactive purge

From Harvey Rutt

Paul Collins is correct in saying that tritium is an unstable isotope of hydrogen (6 December, p 33). However to call it “very dangerous” is misleading.

Externally, it presents no hazard, the radiation does not penetrate the dead layer of the skin. It can indeed be incorporated in body fluids, but the body turns over its water content rapidly, and so you quite quickly get rid of it.

Years ago, radiation workers who ingested tritium were sent down the pub for a few beers, to turn it over faster!

The low-energy beta particles that tritium produces are rather ineffective at doing biological damage, even when inhaled or swallowed.

In fact the “permitted body burden” for tritium is far higher than for any other isotope I know of. So tritium, while certainly not to be treated lightly, is probably

the safest radioactive isotope there is in routine use.

Southampton, UK

Well-heeled

From Ron Davis

Corrinne Burns’s article on how altering the sound of your footfall can change how you feel reminds me that in Canada during the 1950s there was a fad for metal strips on the bottoms of shoes (22 November, p 40). These made loud clicks as you walked.

Their wearers affected conspicuous clothing and an insouciant gait. I thought all these features were components of a specific style, but Burns’s article indicates that the clickers were perhaps driving the other features of the style.

The fad quickly faded when people realised the damage metal clickers did to hardwood floors.

Deep River, Ontario, Canada

Follow that bee

From Marco Overdale

In his letter defending the invasive plant Himalayan balsam, Granville Tunnicliffe Wilson mentions that bees return to his hive covered with its characteristic pollen, but he doesn’t know where they have found it (20 September, p 31).

Perhaps he should observe the famed bee dance of returning workers. This will give him direction and distance to the plant in question.

Wellington, New Zealand

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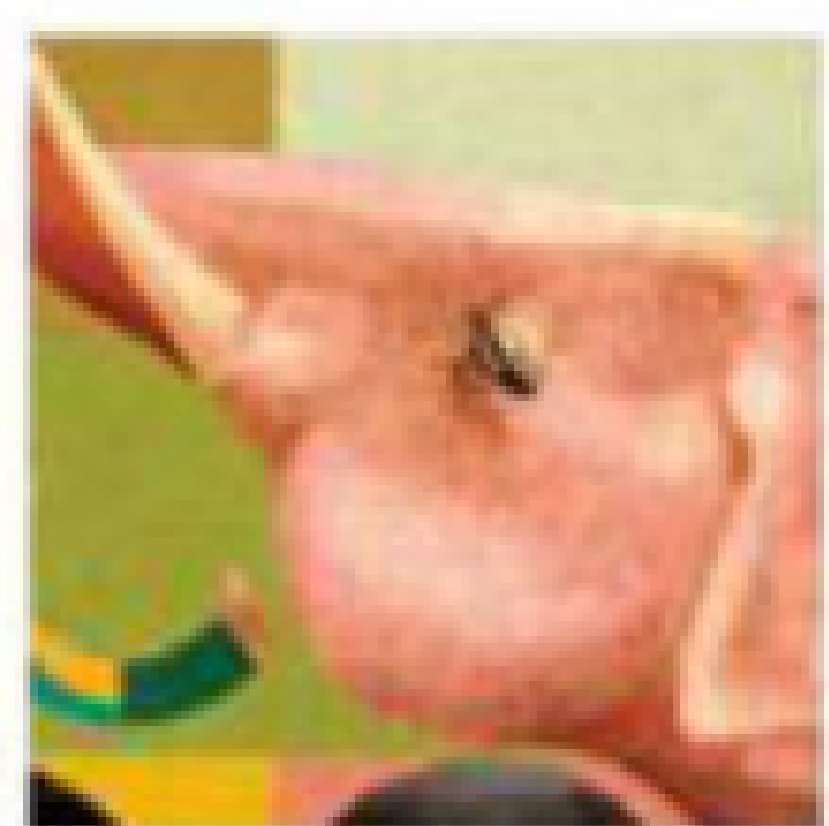
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Get in the

Ever seen a bonobo on the bongos, or a rockin' cockatoo? Find out why only some animals got rhythm in our bumper 32 page holiday features section. Also featuring spiders that give gifts, computers that write crosswords, chocolate's little helpers, the man who ate himself drunk and more

festive groove



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Beastly beats



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Why we love reverb... erb erb erb



73

Eat yourself drunk



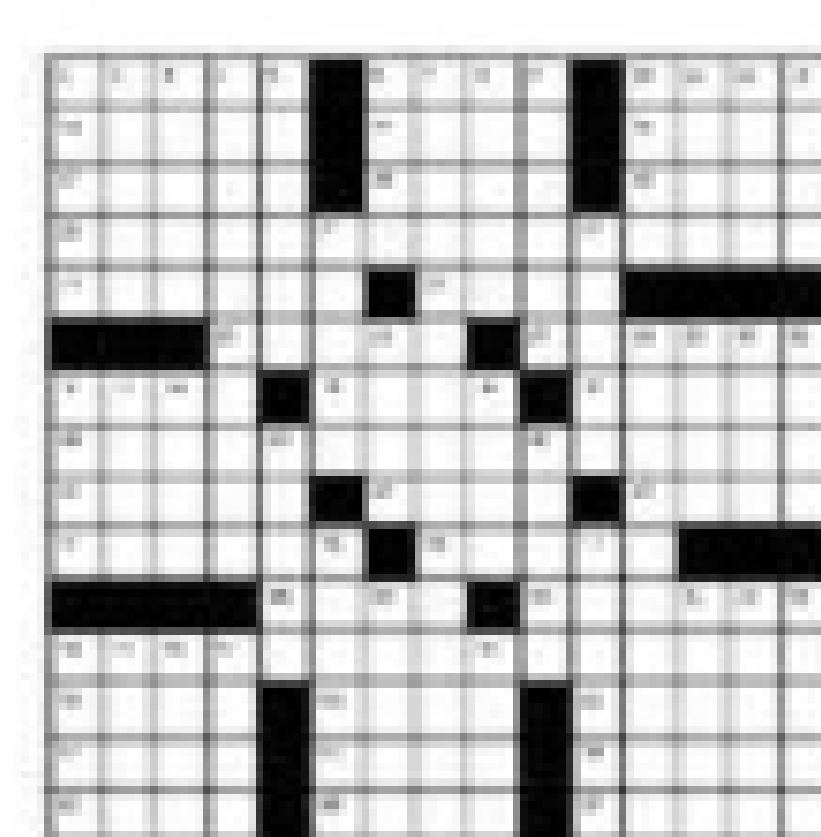
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Who reached the North Pole first?



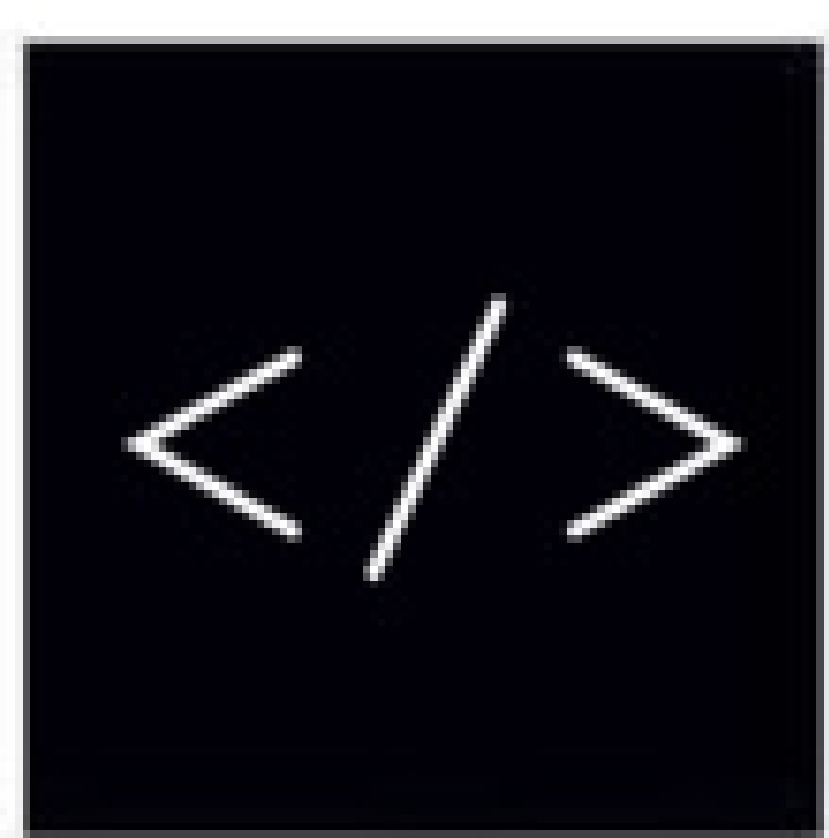
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The eight legs of Christmas



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Rhyme and reason



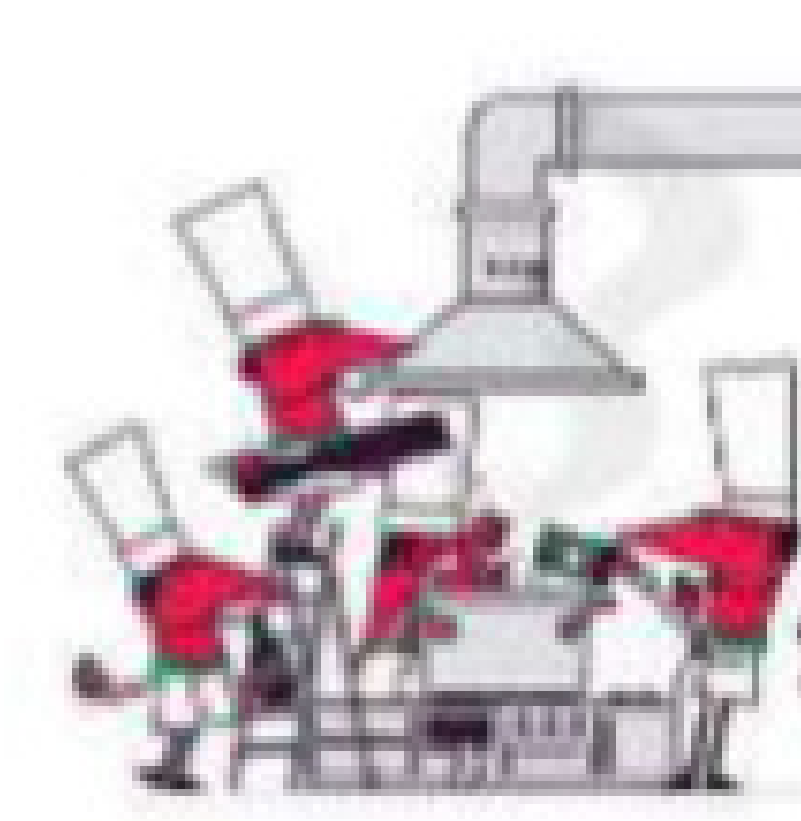
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Readers of the storm



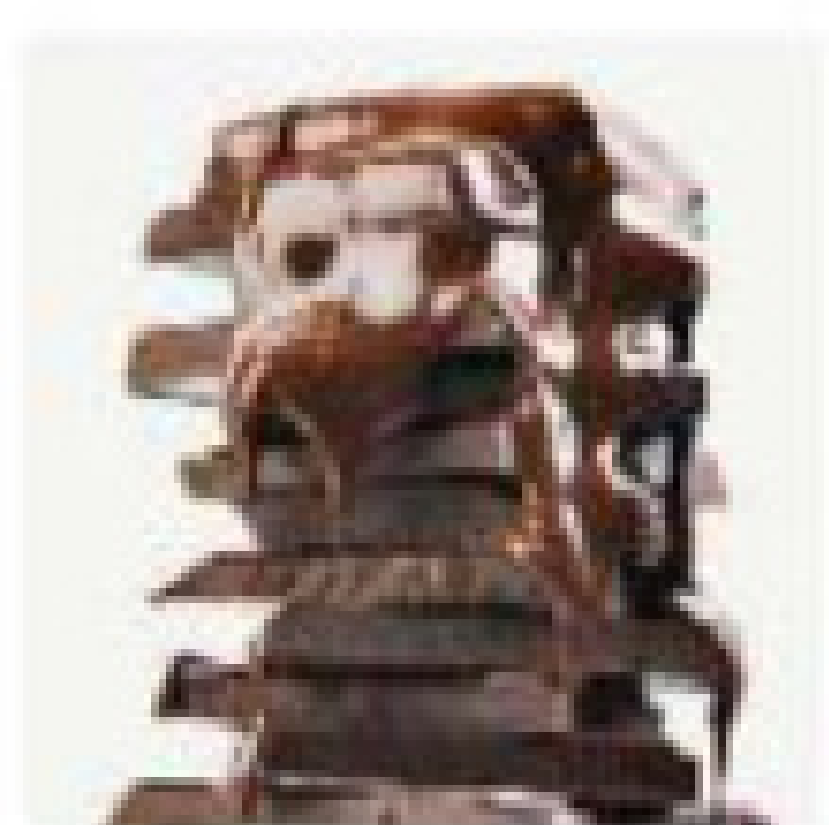
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Fold your own universe



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Pearls of wisdom?



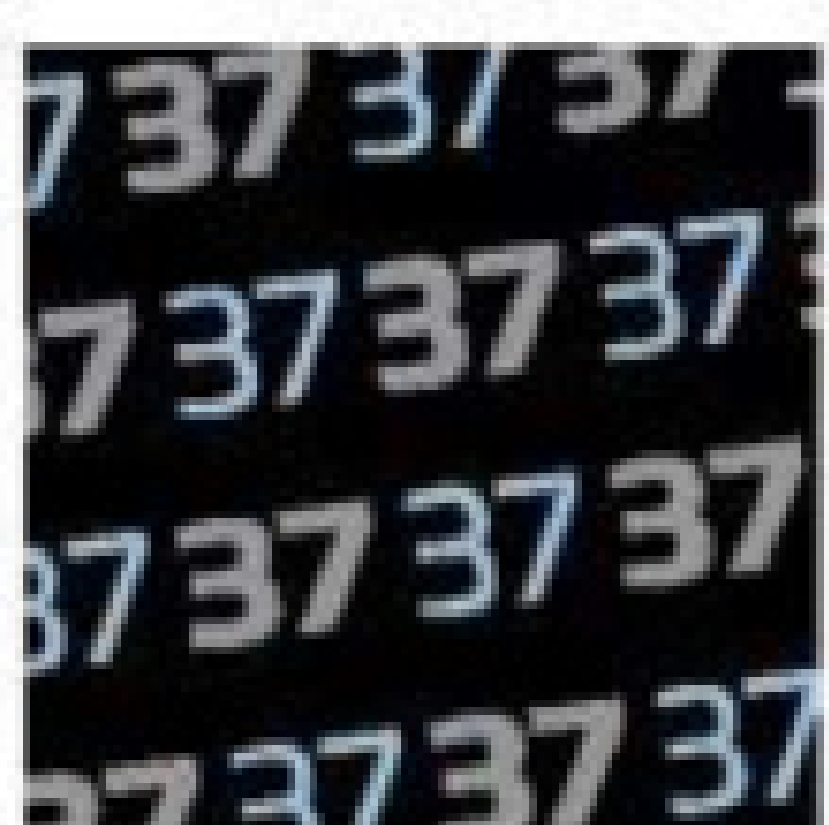
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The real Oompa-Loompas



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Winter wonderworlds



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The answer to life, the universe and everything



Beastly beats

Which animals were born to dance?

David Robson finds out

THE Remo drum company has provided kits for the Beatles, Led Zeppelin and the Rolling Stones. But the rock-and-roll antics of a recent group of clients is in a different league. “These guys will sit on a drum, they’ll pee on it, they’ll chew it, they’ll try to pick it apart with their fingers,” says Edward Large. “It really needs to be indestructible.” He’s not wrong. They trashed their first set of bongos within a week – and they hadn’t even played them. But then, they are bonobos.

It wasn’t until the company came up with a more robust kit – made from the material used to upholster pick-up trucks – that the beat could start. Like most animals, bonobos don’t share our love of a beautiful melody or exquisite harmonies. But, in recent years, the rudiments of rhythm have been found in a surprisingly diverse menagerie. So Large, a psychologist at the University of Connecticut, wanted to find out whether bonobos would take to the drums. This wasn’t simply for fun. Understanding why some species can tap out a beat but others can’t could reveal the origin of music and shed light on our own journey to becoming the all-singing, all-dancing ape.

Charles Darwin described music as our “most mysterious” faculty. He suggested

it began with a “musical protolanguage” – a kind of vocal mating display akin to birdsong – that eventually diverged into two separate traits: speech and music.

Others see music as “beneficial play” – prehistoric brain training that challenges various mental skills, such as memory and the perception of emotion. It has also been described as “auditory cheesecake”, a pleasurable experience that just happens to occur as the result of other mental traits we possess such as pattern recognition. Unfortunately, there has been little evidence to back up any of these ideas. Now a switch in focus to rhythm, rather than pitch and harmony, has changed all that.

Researchers have found few universal patterns in the way different musical traditions combine pitches. But rhythm is different – while drumming may not be for everyone, dancing to some kind of beat occurs in almost all musical cultures.

What’s more, unlike an understanding of harmony, a sense of rhythm seems to be innate. Play drum tracks to newborn babies whose skulls have been covered with electrodes, and there is a spike in neural activity when a drummer skips a beat, as if they have perceived the rhythm and noticed an error. All of which points to rhythm as one of our most primal musical traits.



GONÇALO VIANA



Even so, other animals weren't thought to share our sense of rhythm. Aniruddh Patel, now at Tufts University in Massachusetts, was one of the first to question this notion. He suspected that complex communication set us on the path to music, reasoning that speech relies on the same connections between auditory and motor areas of the brain that produce rhythmic movement. Although no other species has language, some are capable of flexible, learned vocalisations. If Patel was right, these creatures – which include songbirds, cetaceans and parrots – should all have a sense of rhythm.

In 2009, Patel saw the perfect opportunity to test the idea when a colleague emailed him a link to a YouTube sensation called Snowball. In the video, the sulphur-crested cockatoo could be seen rocking his body in time to the Backstreet Boys' song *Everybody (Backstreet's Back)*. Patel emailed the bird's owner, Irena Schulz, and together they showed that Snowball could also bob his head in time to versions of the song that had been accelerated or slowed down. Patel was delighted. "I saw it opening up a lot of future research," he says.

"The bonobos trashed their first set of bongos within a week"

And he was right. Soon, Adena Schachner and her colleagues at Harvard University were combing YouTube for more dancing animals. They found signs of rhythm in 14 other species capable of vocal learning, including macaws, parakeets and Asian elephants. A further 500 videos showed animals with limited vocalisation, such as dogs, ducks and owls, moving to music but failing to keep time, strengthening Patel's hypothesis.

But last year, the first notes of discord began to sound. First came Ronan, a young sea lion at the Long Marine Laboratory at the University of California, Santa Cruz. Sea lions aren't thought to be vocal learners. However, after a year of training, Ronan could easily match Snowball in a dance-off. Besides bopping to *Everybody*, she shimmied her way through Earth, Wind and Fire's *Boogie* ➤

Wonderland – a more difficult task, given the many tempo changes within the song. Despite the challenges, it seemed to be her favourite tune. “With *Everybody*, she soon got irritated and quit,” says her trainer Peter Cook. “But when we gave her *Boogie Wonderland* she just hit it and didn’t get tired. She still loves it, to this day.”

Beat generation

Then primates got in on the act. Our closest relatives all have a very limited repertoire of calls. Nevertheless, in 2013, Japanese researchers reported that a chimp called Ai had learned to tap a keyboard in time to a simple backing track. And this February, Large announced exciting results from the bonobos at Jacksonville Zoo and Gardens in Florida.

When Large set up his drum kit and began to jam in a walkway between the bonobo enclosures, he attracted an enthusiastic audience. “They came and sat around us to listen in silence. It was rapt attention, and when we stopped they all started screaming for more.” After some coaxing, two bonobos eventually started to drum along with researchers and, in tests around their preferred tempo – which reached a whopping 278 beats per minute – they kept to the beat in about 40 per cent of trials.

What are we to make of these results? Patel isn’t giving up on his idea. The bulk of animals with a sense of rhythm are still vocal learners, he points out. The bonobos only synchronised with a single drumbeat, not complicated, multilayered music. He admits that Ronan’s dancing is intriguing, but argues that sea lions may be more loquacious than we realise given that there are very few studies of their vocalisation. Most other researchers suspect there is a spectrum of abilities – and that vocal learning may be only one of many factors that imbue some species with the ability to beat time.

For instance, there may also be a link between a sense of rhythm and social behaviour – especially the need to coordinate actions. In other words, rhythm acts as a kind of social glue. Ronan’s grooves certainly seem to support this idea; sea lions often swim in packs to help them flush out their prey.



Can you spot which one is the dad dancer?

Likewise, bonobos and chimps both live in relatively large groups that require individuals to evaluate and respond to the actions of others. Perhaps predicting the timing of group movements, and synchronising your own actions with those of others, strengthens the neural circuits involved in rhythm.

Our ancestors would have needed social coordination for activities such as tool-making, hunting and preparing food. Over time, such behaviours may have become overtly rhythmic, since working to a beat helps people to coordinate their actions – just look at the work songs such as sea shanties in our recent musical history.

Repetitive, rhythmic movements may also have developed to help groups



resonate emotionally, deepening the social bonds that are crucial for human survival. Studies show that children who dance together are more cooperative in subsequent games. Adults who march, sing or dance as part of a church, army or community group are more likely to work for the good of their group than those who don’t. And when two people bop to a steady beat, they are more likely to rate the other person’s personality as similar to their own than couples who move out of time.

Over the millennia, our ability to perceive a beat has expanded our musical horizons far beyond those of Large’s bonobos. Rhythm is in our nature, even if we don’t always display it on the dance floor. Like Snowball, Ronan and the other YouTube boppers, we are born to groove. ■

David Robson dances to his own beat

MAIN: STEVEN KAZLOWSKI/REX; LEFT BOTTOM: JONATHAN BIRD/GETTY; LEFT TOP: BIRDLIVERS ONLY

Pole position

Who won the race to the top of the world? **Stephen Battersby** finds a new angle on a century-old debate

WHEN Robert Scott reached the South Pole in January 1912, he found an actual pole. It was holding up a tent left behind by Roald Amundsen five weeks earlier. Inside was a note for Scott. There could be no dispute about who had got there first.

On the other side of the world at the North Pole, any marker left behind soon drifts away with the sea ice, so it was harder for early explorers to prove they had reached it. Frederick Cook was the first to claim he had got there, in April 1908. The feat was briefly celebrated on his return to the US in 1909, but then his honesty suffered a public knock: Cook's previous claim of climbing North America's highest mountain, Mount McKinley, in 1906 was denied by his climbing companion. Matters weren't helped by the fact that Cook's detailed records of the Arctic expedition had been left behind in Greenland.

Instead, the official plaudits – and even a government pension – went to his one-time friend turned rival, Robert Peary, who claimed to have reached the pole in April 1909. Doubts remained, however, especially after a re-examination of the records in 1988 revealed suspicious elements in Peary's story. For example, the pages of his log book are mysteriously blank for the two days he claimed to be at the pole, 6 and 7 April 1909. His navigational readings are written on paper slips that were inserted later.

It has also emerged that Cook's former climbing companion may have been paid by representatives of Peary to discredit Cook, and that Cook's pole records were left behind because the team member who was carrying them ended up travelling back on Peary's ship – and Peary refused to take the records aboard.

So the debate about who got there first continues more than a century on, as Wayne

Davidson found out in 1997 when he met a group of explorers from New Zealand. "They were divided into a Cook gang and a Peary gang," he says, "and they argued all the way to the North Pole." That led Davidson to wonder whether his own Arctic observations might be able to resolve the argument.

Davidson is a meteorological observer based in Resolute on Cornwallis Island in

Nunavut, Canada, which, at a latitude of almost 75° north, is deep inside the Arctic Circle. His particular interest is refraction in the atmosphere. This is essentially the same as what happens at the surface of a pond or a piece of glass: when a ray of light goes through regions with different optical properties, it gets bent.

We rarely think about this happening in the air, says Davidson, but it is everywhere and it distorts our view of the world. "The horizon and everything around us is constantly shifting," he says.

Under some conditions, refraction can even turn things upside down.

When a warmer layer of air sits above a cooler layer it can bend light so strongly around the curvature of Earth that it creates a type of mirage called a Fata Morgana. In the Arctic, this ➤





Soon this sign will go with the floe

can lead to an apparent wall of ice rising before an explorer.

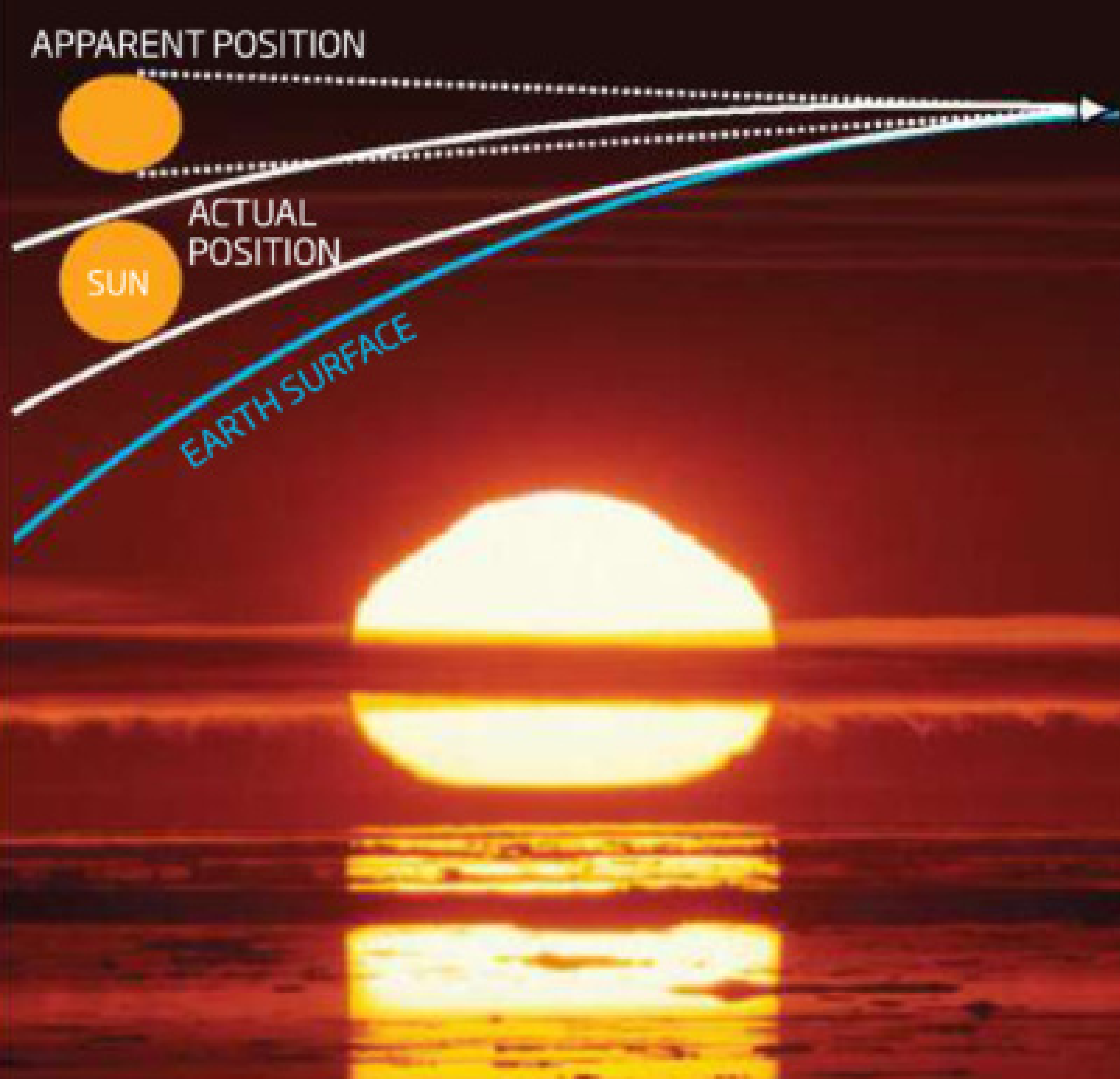
Usually the effect is more subtle. As the sun sinks close to the horizon, it appears a little bit squashed. That's because to reach your eye, light from the lower edge of the sun has to travel through denser air closer to the ground, bending it more than light from the upper edge (see diagram, right). This is what Davidson has been recording for many years. "I'm the only one in the world to specialise in refraction of the sun disc," he says.

The amount of flattening depends on the angle of the sun in the sky, along with fickle atmospheric conditions, but Davidson believes that his database is large enough to test the observations of Peary and Cook. These explorers used a sextant to measure the height of the sun above the horizon, which along with the date and time (supplied by a chronometer) enabled them to calculate their latitude. They took the position of the top and bottom of the sun to get an average – and in the process they happened to measure the size of the sun disc.

Peary's readings, as written on those infamous inserts, put the sun at 6.7 degrees from the horizon. According to Davidson's database, at that angle the atmosphere should squash the sun's

Trick of the light

The bending of light rays in Earth's atmosphere can make the sun appear higher and flatter – suggesting some Arctic explorers' solar observations were way off-beam



PAUL NICKLEN/GETTY

vertical diameter to something between 31.19 and 31.49 arc minutes. Peary's record gives values ranging from 31.58 to 32.17 arc minutes. Only one of Peary's numbers is plausible, with the others impossibly large. The biggest is even larger than the undistorted diameter of the sun, 32 arc minutes. Atmospheric refraction doesn't magnify the sun.

As an experienced surveyor, Peary should have been able to get readings

with an error margin of no more than 0.2 arc minutes, says Davidson. "So I'm having trouble with this guy now. Someone good at surveying would have noticed such unusually inflated measurements, prompting an immediate rejection. This suggests he made no observations there."

But if you are going to cheat, why insert impossible readings? Davidson speculates that after the expedition, someone with access to Peary's archive but limited navigational knowledge made up the numbers. In any case, the strange readings cast doubt on Peary's reliability.

Does this mean redemption for Cook? Hardly. One of his measurements has the sun disc at 26.5 minutes. This is way outside the range in Davidson's database, suggesting that Cook was very sloppy in his measurements. "He had huge variations far greater than I ever measured. After all he was a physician, not a physicist."

There is a glimmer of consolation. In one of Cook's observations, he records seeing the sun when it was actually 5 degrees below the horizon. This may sound like another mistake, but in fact such extreme refraction can happen far out on the flat Arctic ice. So while some think that Cook didn't even venture far out on the ice, this suggests otherwise.

Overall, it seems that neither Peary's nor Cook's claims can be believed. "I'd say neither of them made it to the pole," says Davidson. He isn't the first to make this suggestion. Explorer Wally Herbert, who carried out the 1988 re-examination, concluded that Peary missed the pole by about 100 kilometres, taken off course by the drift of the ice. Herbert wasn't entirely disinterested, however: if neither Peary nor Cook got there, it would mean Herbert himself was the first person to reach the pole on foot, in 1969.

Davidson's findings at least add another line of evidence, though the Cook and Peary camps will no doubt keep squabbling. Instead of wrangling about the past, perhaps we should instead look forward to another record that will be up for grabs some time later this century: the first person to reach the North Pole by kayak. ■

Stephen Battersby only got as far as Iceland

Can computer code be poetry? [Niall Firth](#) parses a new literary phenomenon

Rhyme and reason

ON STAGE at Stanford University in California last February, the words of Beyoncé were being intoned as a religious text. Next came Richard Branson. Then Elon Musk.

This was the second Stanford Code Poetry Slam: a celebration of code poetry, a reimagining of computer programming languages as a form of literary expression. The winner, Hunter Bacot, had written a short, elegant program called *21st Century Prophecies* that pulled in the latest tweets from a selection of famous names to be read out as if they were sacred commandments. The crowd went wild.

“It’s really interesting to see language in a new way,” says Melissa Kagen, who organises the Stanford slams. “People have been writing in English for so many years. This is a whole new medium and a whole new set of possible metaphors.” The results are always unusual, often complex and occasionally moving.

The definition of code poetry is rather broad. In its purest sense a code poem is a piece of code that runs as a program but also works, on some level, as poetry. These create some of the most effective and dramatic poems.

But the slam also accepts entries that use what Kagen calls “coding idiom” to create a distinct poetic effect. For example, one of this year’s finalists, *Apache Code Errors*, used a list of error messages from Apache server software –

Some code poems are “poem generators”. *Me and You* (right), written in Python, composes short poems by picking lines at random from the given list

which runs much of the web – to tell the story of how Native Americans in the US lost their land. Another, *Capsized* by Zachary Kain, was written in CSS, a language used to style web pages, to describe a boating accident (see page 52). “It was lovely and so short. Ambiguous and quiet,” says Kagen.

The Stanford slams add a new element – poetry as performance. Often a code poet will climb on stage and recite the poem as they type it out on a laptop, with the live coding projected on the wall. “Poetry is beautiful on the page, but you also get something out of it out loud that you don’t just from reading it,” says Kagen. “We wanted to explore the mouthfeel of a code poem.”

The concept of code as verse won’t be new to many programmers: good poetry and well-written code have much in common. Both contain densely packed information that is nested within something that has been elegantly written. No lines are wasted. ➤

Me and You by MATTHEW LEE

```
import random
```

```
traits = ["only speak when spoken to", "never know how to introduce myself", "hide in the middle of a group", "lead in the front", "make my opinions known", "do all of my homework", "have a plan", "know what will work and won't", "believe in true love", "get caught in the past", "know the future will be better", "want to please", "set goals", "smile at strangers", "watch my feet when walking", "look for things to do", "let things unfold", "climb trees", "keep my feet on the ground", "walk fast", "drive slow", "read the newspaper", "watch cartoons", "eat breakfast", "believe in the midnight snack", "snore", "yawn loudly", "love vegetables", "eat gluten-free", "get cold easily", "need a hug", "get lost in eyes", "hate my reflection", "sing in the shower", "give others the benefit of the doubt", "double-check the lock on the door", "watch the sunrise", "floss", "hide my scars", "listen to Chopin", "keep a diary", "scrapbook", "knit", "sweat a lot", "wash your hands before eating", "pray"]
```

```
def Me():
    my_trait = traits[random.randint(0, len(traits)-1)]
    print "I " + my_trait + "."
    return my_trait
```

```
def You():
    your_trait = traits[random.randint(0, len(traits)-1)]
    your_trait = your_trait.replace("my", "your")
    your_trait = your_trait.replace("am", "are")
    print "You " + your_trait + "."
    return your_trait
```

```
def WillItWork(me, you):
    print "Will it work?"
    willitwork = random.choice(["Yes", "No"])
    print willitwork + "."
    if willitwork == "No":
        print "Will it be okay?"
        print random.choice(["Yes", "No"]) + "."
```

```
me = Me()
you = You()

WillItWork(me, you)
```

I look for things to do.
You hate your reflection.
Will it work?
No.
Will it be ok?
Yes.

Capsized

by ZACHARY KAIN

```
.ocean {  
color: cornflowerblue;  
pitch: high;  
overflow: visible;  
}  
  
.boat {  
color: firebrick;  
transform: rotate(94deg);  
float: none;  
}  
  
.rescue-team {  
visibility: visible;  
}  
  
.crew {  
widows: none;  
}
```

Although it helps if the reader has a certain familiarity with the coding language being used, non-coders can still enjoy trying to grasp hidden meanings. Nevertheless, in-jokes for coders abound, like the use of a looping program to depict the repetitive arguments of a failing relationship in Sandra Trinh's *If Nothing Else*.

It has even caught the eye of a few mainstream poets. "I love the way punctuation becomes more than a guide for making sense of the language," says UK poet Amy Key. "It is almost ornamental."

For Ben Allen, also at Stanford and a co-organiser of the most recent slam in November, code poetry is interesting not just for any literary merit it might have, but also for what it tells us about coding languages themselves. "It's a way of exploring the boundaries of this distinct mode of expression that's become so important to our lives," he says, "to continue the debates from early computing about how language-like code could be, or should be." ■

assert(is_amateur_poet("Niall Firth") == true)

Fold your own universe

The secrets of the cosmos are encoded in origami, says [Stephen Battersby](#)

OUR universe was shaped by origami. Gravity took a primordial paper sheet and folded it to form galaxies, thus bringing light and life to the cosmos.

This original take on the creation myth is more than just empty metaphor. One astrophysicist is discovering how origami can tell us a few things about how galaxies are created, why they tend to spin in unison – and how in their early days they may have been nested within vast, dark polygons.

Mark Neyrinck of Johns Hopkins University in Baltimore, Maryland, studies how galaxies and other structures form. Specifically, he looks at how dense spots of invisible dark matter suck in enough normal, gassy matter to create galaxies. In 2011, Neyrinck went to a talk by origami master and former physicist Robert Lang. "He described spacecraft solar panels that unfold origamically," he says. "I wondered if some of the origami mathematics he described could be of use in cosmology too."

To see why it might be, we must take a trip to the sixth dimension. All matter in the universe has a position in the three dimensions of ordinary space. It also has motion, which can be plotted in an abstract space with three dimensions of

its own. Physicists often seek insights by plotting position and motion together in one grand 6D arena called phase space.

Immediately after the big bang, matter was spread almost evenly throughout the three dimensions of position. Although space-time was itself expanding at a tearing pace, the matter wasn't moving much relative to this stretchy background, so all its motion coordinates were zero. In 6D phase space, it forms a flat 3D sheet.

Then gravity began to pull matter towards any slightly denser patches. Viewed in phase space, movement means that the 3D matter sheet bends out into the dimensions of motion. As these movements become more pronounced, the sheet twists around and overlaps itself – a bit like a fold.

More folds mean higher density as more matter is overlapping. Rather as when you fold a sheet of paper by hand, what tends to happen is that many-folded florets (very dense) tend to be joined up by less folded strips (less dense), with big gaps in between where the matter sheet is still flat (least dense). The result looks much like the large-scale structure of the universe today, where dense galaxy clusters are joined



In the origami universe, galaxies and galaxy clusters form where the density of folds is greatest

Connecting folds represent the filaments of matter that connect galaxies and clusters

Unfolded areas equate to the voids between galaxies

by filaments into a network of matter, with voids in between.

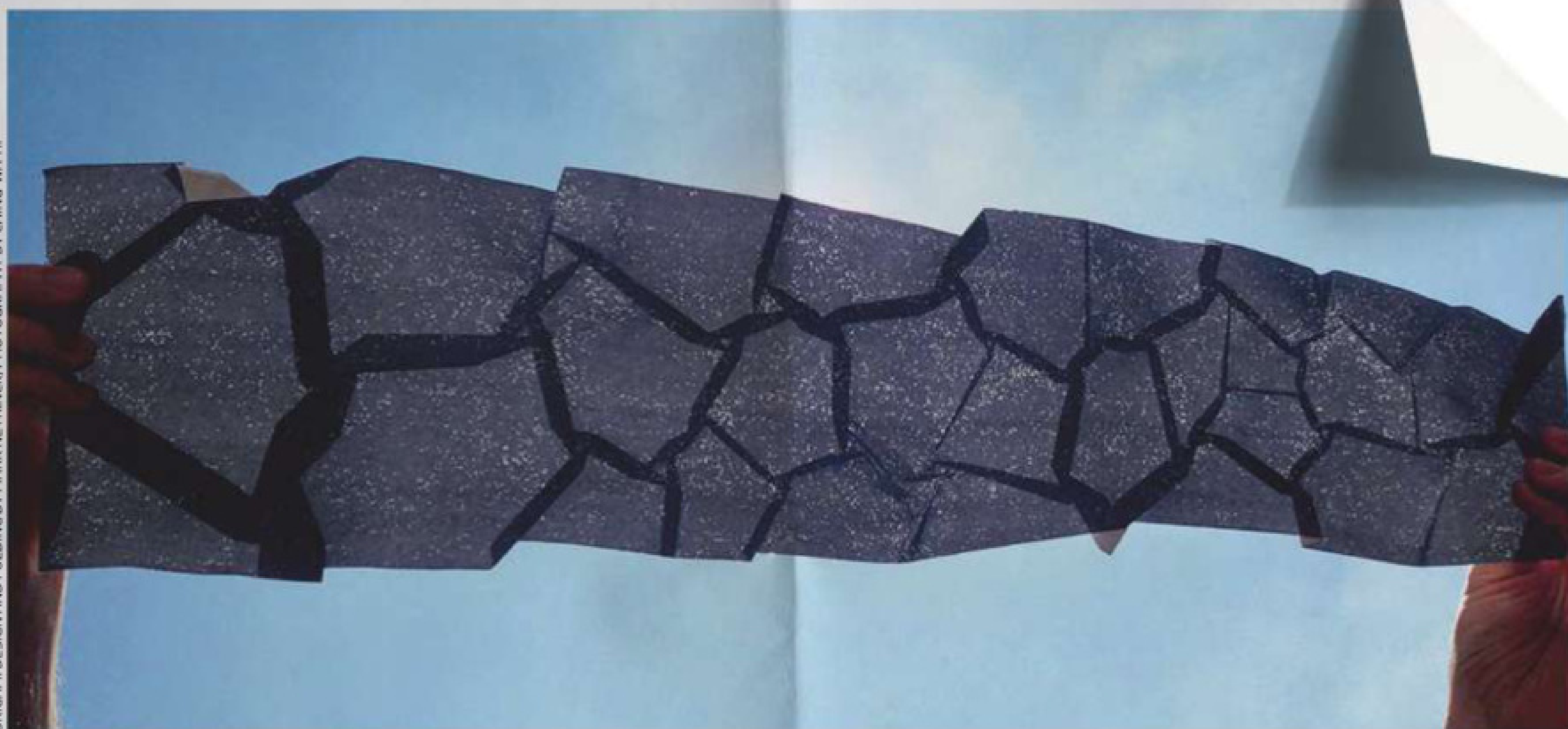
Origami isn't exactly the same as the real universe, of course. Paper can't stretch, while gas and dark matter can. But the idea captures a lot of the essential physics, while being much simpler than the gargantuan simulations required to model galaxy formation. A couple of years on from those first folds, the approach is now promising dividends.

"Origami captures a lot of the essential physics of galaxy formation"

"Finally we're getting to the point where origami mathematics should directly help in comparing theory to observations of galaxies," says Neyrinck.

For one thing, it could help map dark matter. Dark matter far outweighs the ordinary stuff of interstellar gas, dust, stars and us. Being invisible, however, it is only known through its gravitational influences, such as the way it bends the light reaching us from distant galaxies, slightly distorting our view of them.

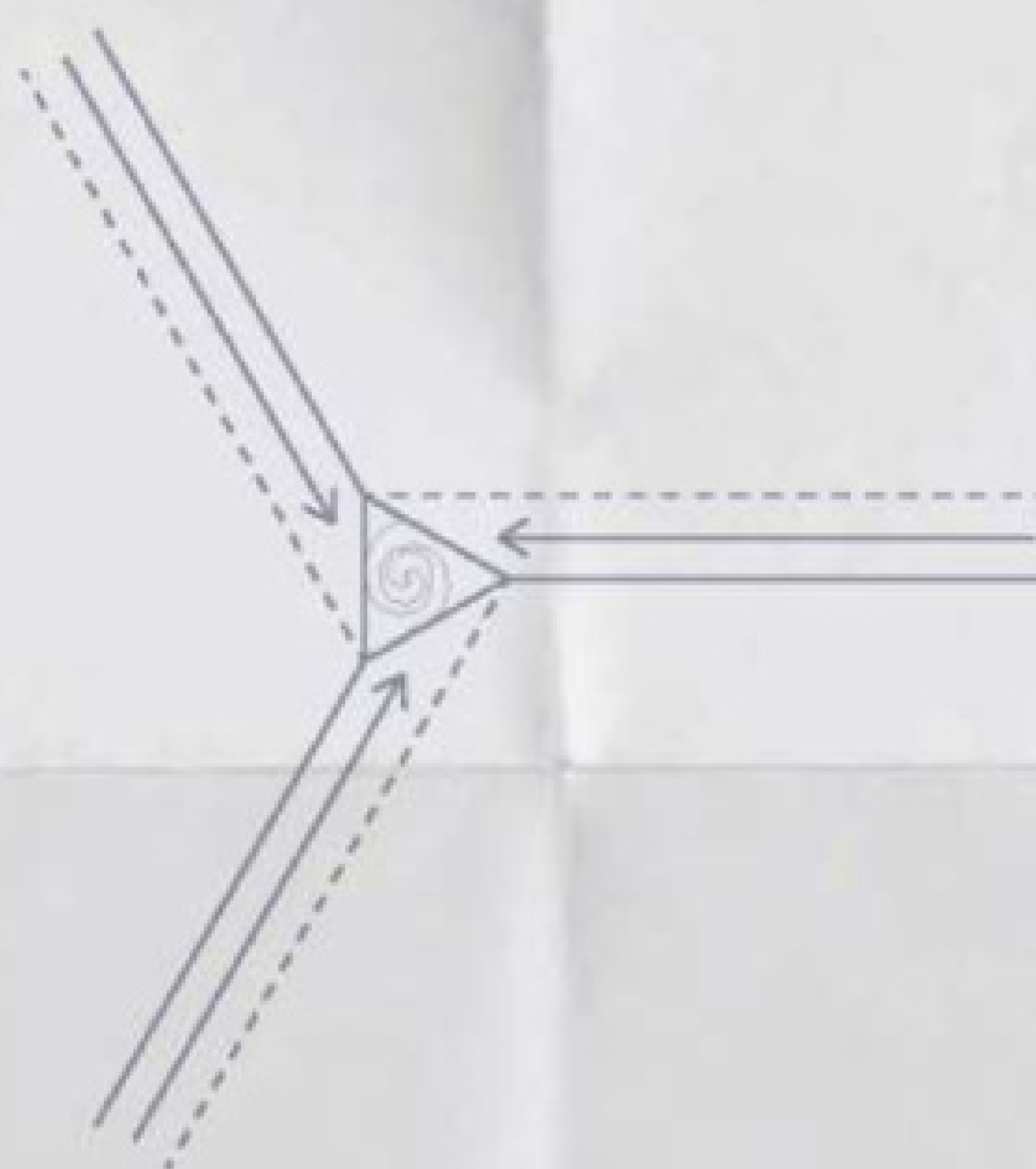
We can use this "weak lensing" effect to trace dark matter, but the method ➤



would be improved if we knew what the galaxies actually look like. While the simplest assumption is that they are oriented randomly, simulations and observations both hint that galaxies line up a little with their neighbours.

Origami agrees. When you fold a set of galaxies from a single sheet of paper, they tend to have similar orientations – because of those folds representing the filaments of inflowing matter that connect them. These streams of matter piling into a galaxy are what sets it spinning, so being joined together by filaments causes neighbouring galaxies to spin around similar axes of rotation. This in turn affects their shapes, flattening them out. So origami theory could give a better idea of the true orientations of distant galaxies, and help in tracing the distortions caused by intervening dark matter.

Cosmic origami also has a rather beautiful consequence. We know that every galaxy sits at the centre of a blob of dark matter called a halo. Analysis of simulations in 2014 shows that these haloes may have much sharper boundaries than previously thought. This, too, comes naturally out of the origami approximation. But while most researchers assume that these boundaries are rounded ellipsoids, Neyrinck's origami simulations suggest something different, more like an irregular polyhedron. "A real halo would be in between a polyhedron and sphere – plus some other small-scale structure,"

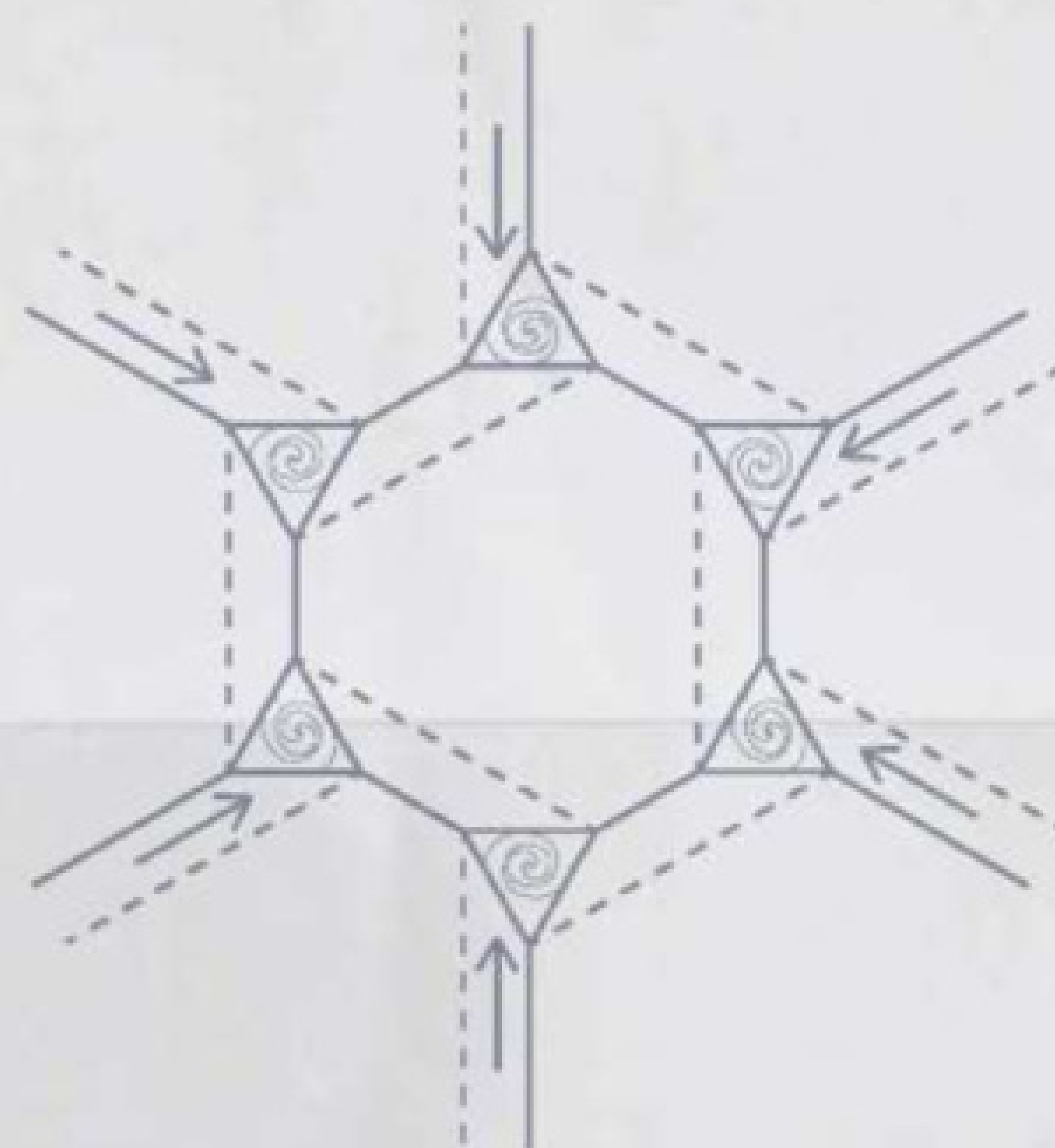


Origami faithfully reproduces the cosmos – whether across a wide swathe of sky (top) or for single galaxies or a small cluster (above)

he says. If so, then each new galaxy is formed within a vast faceted gem of dark matter.

You can see Neyrinck's patterns for a single galaxy, and a cluster of six surrounding a void, above. If you'd like to test how it feels to play gravity by folding your own, go to the *New Scientist* website at bit.ly/NSorigami for larger printable versions.

If you are an origami novice like me, you may struggle to make a neat job of even the six-galaxy cluster. Neyrinck himself has become an old hand at paper folding. He uses a computer to simulate origami galaxies, but backs it up by hand, using a blueprint printer to lay down the pattern of creases. You



can see one result at the top of this page. The background image is a slice through the universe showing the position of galaxies stretching across a few billion light years, courtesy of VIPERS, an ongoing galaxy survey being performed by the telescopes of the European Southern Observatory in Chile. Superimposed is Neyrinck's origami pattern that neatly reproduces the distribution of galaxies within it – with each node in the folding pattern not a single galaxy, but a supercluster of galaxies.

Neyrinck's origami output has remained focused on work, however. "Not much decorative stuff. Mainly galaxies," he says. This may have to change one day when astronomers find a distant cluster of galaxies that takes the unmistakable form of a flying crane. ■

Stephen Battersby collapses like a badly folded deckchair



Chocolate's dark secrets

What turns raw cocoa pods into the world's favourite confectionery, wonders
Lesley Evans Ogden

IN THE fictional chocolate factory of Willy Wonka, small cheery folk called Oompa-Loompas do the hard labour of making chocolate, and are paid in cocoa beans. In real life, the chocolate workers are much, much smaller. Before cocoa beans can be dried, roasted and made into the good stuff, they must be fermented – and this job falls to a host of microbes.

The surprise is that it is largely left to chance which microscopic minions participate. Whereas fermentation in other foods tends to be controlled by adding just the right mix of microbes, in chocolate the process is still usually spontaneous. But leaving everything up to nature is risky. As global demand for chocolate grows, and supply is imperilled by diseases affecting cocoa trees, microbiologists and chocolatiers have embarked on a quest to give cocoa bean fermentation a helping hand. That is great news for chocoholics everywhere, as it promises to keep the chocolate river flowing. It should improve the quality of our favourite confectionery, too.

Pulpy mass

The journey from ripe cocoa pod to chocolate is complex. Fermentation is the critical first step. "Cocoa beans have to be fermented and dried before they can be used as the raw material for chocolate production," says Luc De Vuyst at the Free University in Brussels, Belgium. Each pod contains 30 to 50 beans, embedded in the slimy pulp of the fruit. At harvest time, pods are plucked from the trees, opened with a knife, and the contents scooped into a giant heap on banana leaves or in a wooden box. Microbes in the air, soil and leaves – and on the knives and hands of farmers – inoculate the pulp, and the transformation begins.

The pulpy mass is packed so tightly that oxygen cannot penetrate, and it starts to ferment. Wild yeasts initiate the process, converting the sugars glucose, ➤

SHIMON AND TAMMAR/GALLERYSTOCK

fructose and sucrose into ethanol, just like in the production of beer or wine. Alongside yeasts are ethanol-tolerant lactic acid bacteria that convert sugars and citric acid into lactic acids, similar to the process that occurs in yoghurt and cheese. As the yeasts do their work, they also produce enzymes that attack the viscous pectin in the pulp, turning it into a sweaty liquid, which slowly oozes away.

Ethanol production requires a low-oxygen environment and, as air enters the heap and liquid departs, this process slows down. Airflow allows a boom in a third class of microbes: acetic acid bacteria. These oxidise the ethanol into acetic acid in a reaction that heats up the whole pulpy mass to between 45 °C and 50 °C. Unable to stand the heat, the yeasts, lactic acid and acetic acid bacteria all die. Some 72 hours after the process begins,

all the microbes are dead and fermentation stops. Meanwhile, the volatile acetic acid penetrates the beans, killing the embryonic seedlings and starting chemical reactions that generate the precursors of the rich colour, flavour and aroma released when the beans are roasted. From start to finish, the process may take up to 10 days.

“The journey from ripe cocoa pod to chocolate is fascinating and complex”

Left to the vagaries of nature, there is huge variation in the outcome of this so-called spontaneous fermentation. “Many of these fermentations do not run as they should,” says Christoph Wittmann at

Saarland University in Saarbrücken, Germany. Properly fermented, the beige beans should turn a rich dark brown. Some do not ferment, leaving them purple. Others over-ferment, turning almost black. With about one-third of the beans unusable, that’s bad news for farmers who are paid on quality. Around 90 per cent of cocoa plantations are small family businesses, so “this is something we need to improve”, says Wittmann. There are also regional differences in the flavours that fermented beans acquire, depending on things like soil quality as well as the exact mix of microbes that inoculate the bean from the local environment. Typically, chocolate producers blend beans of mixed quality and geographic origins to average out the variation. What they would really like is a reliable supply of high-quality beans – and that means taking control of fermentation.

BOX OF DELIGHTS?

Taste-testing high-quality chocolates is a thankless job, but somebody’s got to do it. At Chocolate Arts in Vancouver, Canada, Mark Pennington lets me try a world-spanning array. The flavour differences are subtle, and I’m initially at a loss for words. Like vintners, chocolatiers have their own terminology, says Pennington, who is Barry Callebaut’s gourmet sales manager for western Canada.

Common descriptors are fruity, earthy, nutty and roasted. A chocolate might be fruity with notes of red fruit like dried cherries, or earthy with hints of grass or moss. Descriptive subcategories could also include vegetal, herbaceous, or asparagus, Pennington says (the latter perhaps not a good thing in either wine or chocolate).

Anya Keefe, co-owner of Krave Chocolat, elaborates on the grape analogy. Cocoa beans from different regions have their own *terroir* – distinctive flavours,

influenced by the surrounding soil, crops and vegetation. Chocolate traceable to a specific region or plantation is known as “single origin”. Keefe’s favourite is grown in the volcanic soils of São Tomé and Príncipe, a small island off the west coast of central Africa. She describes the taste as bright, acidic and earthy, like the smokiness of lapsang souchong tea.

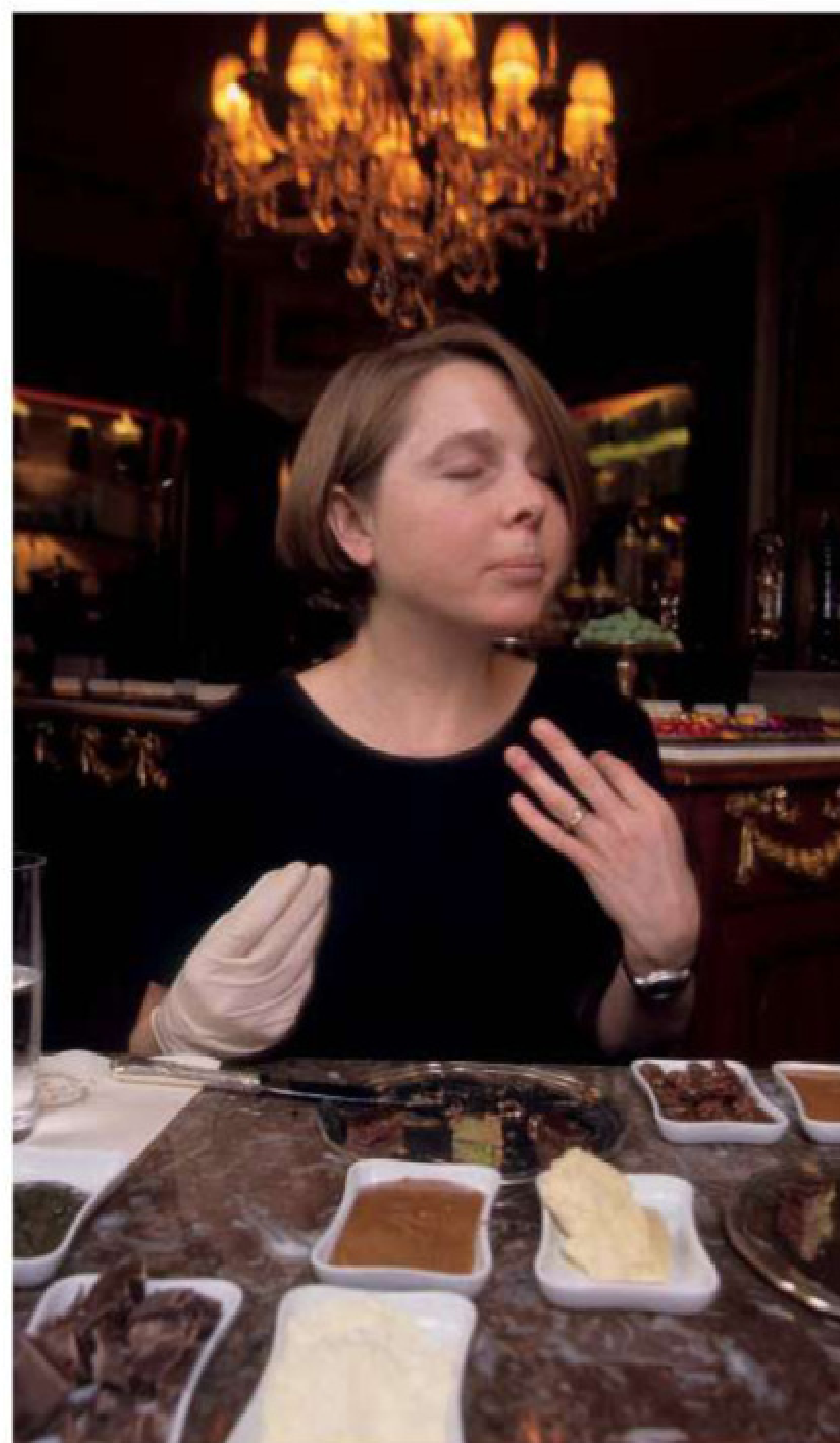
“Tasting is both objective and subjective,” says Eagrane Yuh, a chemist-turned-chocolatier and author of *The Chocolate Tasting Kit*. “I teach people to taste with five senses: look at the chocolate, smell the chocolate, listen to the chocolate’s snap, taste the chocolate (let it melt, don’t munch) and pay attention to its texture.”

Some chocolates naturally have a spicy flavour. “In some of the Caribbean chocolates some swear they taste nutmeg and mace, which is very consistent with what grows around those

plantations,” says Pennington. Good chocolates are often described by their fruitiness – with hints of banana, mango, passion fruit or plum. Chocolates from beans grown in Madagascar are often said to taste like red berries – cherries, cranberries or Swedish lingonberries, he adds.

Armed with my new vocabulary, I did a blind taste test of fine chocolates from Ecuador, Brazil, Madagascar, Tanzania, Venezuela and Ivory Coast. My strong favourite was a delicious, Brazilian single-plantation variety, one I would naively describe as rich, fruity, and floral with hints of coffee.

Interestingly, my second choice was the Barry Callebaut’s “Ocoa” Ivory Coast blend produced by controlled fermentation (see main story). Although my chocolate palette was previously limited to “dark chocolate equals yum”, chocolate-tasting is a new skill I am willing to cultivate.



MICHEL SETBON

So researchers have been finding out exactly which microbes are involved. At the Leão De Ouro (Golden Lion) plantation in Brazil, De Vuyst and his colleagues took a sample 30 hours into spontaneous box fermentation, when all of the major microbial players in the process are well established. They then employed metagenomics, sequencing the DNA of the entire community in one go, to work out the different species present.

Earlier research had indicated striking differences in the microbial community from region to region, but the advanced methods revealed a surprising degree of similarity in the species present. *Hanseniaspora uvarum* was the most common fungus, along with 16 other species. Of the 28 bacterial species they identified, the lactic acid bacteria family Lactobacillaceae was the most abundant (especially *Lactobacillus*, the genus used in the production of yogurt and cheese).

Meanwhile, Wittmann and his colleagues have been looking at the metabolism of *Acetobacter*. They discovered that for optimum performance, these acetic acid microbes need a mix of ethanol and lactate, supplied by both yeasts and lactic acid bacteria. “We now understand who is doing what and why,” says Christoph Bolten at the Nestlé Research Center in Lausanne, Switzerland. What’s important, says Wittmann, is a balanced population structure. So developing a “starter cocktail” of the right mixtures in the right proportions “may strongly improve the quality of the fermentation process”.

Consistent flavours

Vuyst’s team is already on to it. Working with Nicholas Camu from the Belgian chocolate maker Barry Callebaut, they have been testing starter cultures containing various combinations of naturally derived microbes. They found that pulp inoculated with these cocktails fermented in four days – less than half the time it can take with spontaneous fermentation. The beans also gave more consistent flavours. Controlled fermentation is now being used at farms in Ivory Coast, Cameroon and West Java, Indonesia, with early indications that it substantially improves both yield and quality. Barry Callebaut is already marketing chocolate from the beans (see



PASCAL AIMAR/TYENDANCE FLOUE

Handle with care: cocoa beans get their flavour in part from microbes on hands and knives

“Box of delights?”, left).

Of course, chocolate manufacturers are keenly aware that this approach will only be successful if we, the chocolate consuming masses, continue to enjoy their products. Taste is paramount. At the University of Copenhagen in Denmark, researchers funded in part by Danish firm Toms Confectionery Group compared chocolate produced from spontaneously fermented beans with chocolate made from beans inoculated with their own starter culture. An expert tasting panel described the former as “sweet with cocoa and caramel flavours” and the latter as “fruity, acid and bitter with berry, yoghurt and balsamic flavours”. Untrained tasters had no preference. The differences were “too small to significantly change consumer perception”, the researchers concluded. Outside the lab, only time will tell.

Developing and testing recipes for starter cultures is an ongoing global project. Some of the research is

happening behind closed doors. For example, Nina Keller, a spokeswoman for Lindt & Sprüngli, declined my request for an interview with their researchers, saying “we do not disclose our production secrets and insights with the general public due to competitive concerns”. Perhaps it’s more surprising that research funded by the likes of Nestlé, Barry Callebaut, Masterfoods Australia and Toms Confectionery Group is being shared at conferences and published in peer-reviewed journals, allowing all chocolate companies and researchers to benefit from the emerging knowledge.

Purists may be uneasy about these developments. It’s too early to say whether a move towards controlled fermentation will spark a niche market for traditional, spontaneously fermented chocolate. However, if ensuring sustainable quantities of high-quality chocolate is your concern, then the future looks sweet. As for the microbial minions, their story is still unfolding. But as you enjoy your holiday chocolate, spare a thought for these tiny unsung heroes. ■

Lesley Evans Ogden reluctantly takes on the thankless task of testing chocolate

Winter wonderworlds

For the best snow and ice, you need to go way, way off earthly pistes, says [Rebecca Boyle](#)

Few things spell the holiday season like a sprinkling of snow. It may not always be the cold white stuff we're accustomed to on Earth, but there's plenty of opportunity for future space explorers to have winter fun in the solar system ... and beyond.

Heavy-metal snow

As the solar system's innermost planet, Mercury is generally much too hot for a white Christmas. In some spots, however, natural freezers have harboured ice for billions of years. In a single polar crater on Mercury, daytime temperatures can soar above 250 °C, yet patches in shadow stay cold enough to preserve water ice. There is plenty of it, too – in some craters the ice is tens of centimetres thick, with even more buried beneath a thin layer of dust. You could have lunch in a crater's sunny centre (safe from radiation in a special suit) and walk over to a frozen water deposit for an afternoon round of curling.

A little further from the sun, boiling Venus is too hot for snow as we know it. But the planet does get its share of metallic frosting. Temperatures are hot enough to vaporise minerals like pyrite, aka fool's gold, which then falls through the atmosphere as water droplets do on Earth. Volcanoes also pump elements like tellurium into the sky. At high altitudes, this mineral mist condenses and forms a snow-like frost on Venus's tallest peaks.

To reach the finest Venusian champagne powder, skiers must make for Maxwell Montes, 11 kilometres high at the peak (a little more than 2 kilometres taller than Mount Everest). Alpine enthusiasts would need heat-proof pressure suits capable of withstanding temperatures of 400 °C and pressures 90 times those on Earth.

A much chillier environment awaits on the solar system's largest mountain,

towering 25 kilometres above the Martian plains (nearly three times as tall as Everest). Before astronomers knew Olympus Mons was a volcanic mountain, they called it "Olympic Snow" because its peak shone more brightly than its surroundings. We now know these brightness differences are down to volcanic flows and the scouring action of Martian winds. Disappointingly, despite the high altitudes, skiing down Olympus Mons is impossible because its ice and glaciers are long gone.

For more reliable wintry conditions, you want to venture to the Martian poles, which like Earth's are capped with ice, albeit in two forms. Dry-ice snow, made of carbon dioxide, covers a thick deposit of frozen water. And as the Phoenix lander spotted, frozen water also falls as snow, though it vaporises before reaching the ground.

It's autumn right now in the Martian northern hemisphere — good timing for a jaunt to the ice caps, which grow larger in winter and could make great ice rinks. Thanks to Mars's lower gravity, a figure skater could reach unprecedented heights during a triple lutz.

The Europa X Games

If the outer planets in our solar system don't have surfaces where snow and ice collect, their moons certainly do. Europa, a Jovian moon that's slightly smaller than Earth's, has a thin oxygen atmosphere and a thick shell of ice blanketing a vast ocean of water.

"If you smoothed it out, you could go ice skating there," says Cynthia Phillips, an astronomer at the SETI Institute in Mountain View, California.

Last winter, the Hubble Space Telescope spotted evidence of water-vapour plumes erupting from vents on Europa's surface that interact with Jupiter's intense magnetic fields to form

auroras. These appear in ultraviolet, though, so would be invisible to most people with healthy eyes.

Some researchers argue that ice skating requires a minimal amount of melting under the skate, which helps the blade glide over the ice. If that is the case, skating may not work as well on Europa, where surface temperatures are far too cold for ice to melt at all. But there are plenty of other options.

Europa has several ice-filled craters with slopes perfect for ski jumps and half-pipes. "You could ski down a crater,

"Low gravity means you can do some crazy ski tricks"

and since the gravity is less than Earth's, you could probably do some crazy tricks," Phillips says.

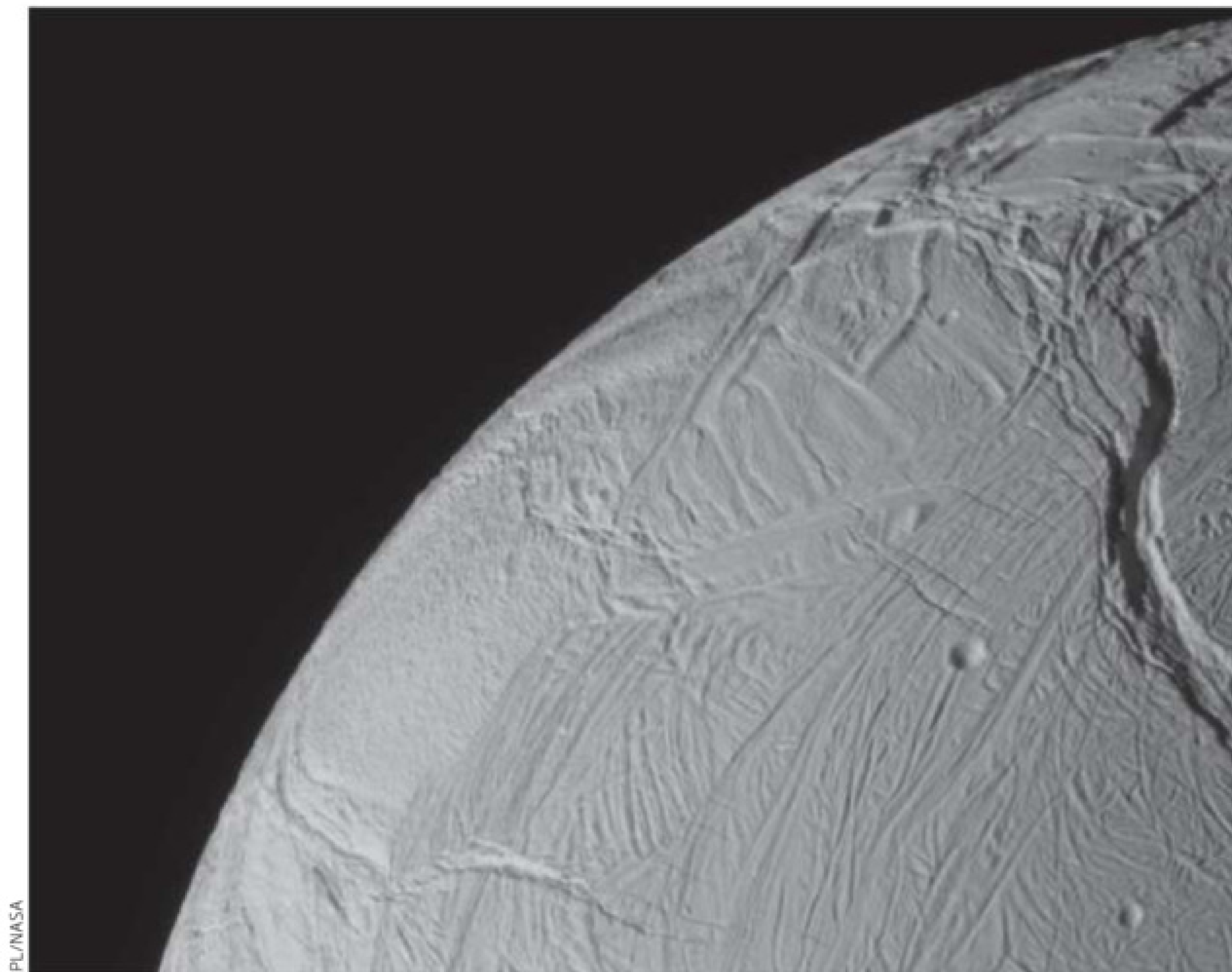
Europa's kilometre-scale ice domes would also be ideal for good downhill skiing, adds Robert Pappalardo, a NASA scientist who studies icy moons. They are rounder and smoother in appearance than the craggy mountain ranges found on Earth, he says.

Meanwhile, the cliffs on Europa's so-called "chaos terrain" would be a big draw for ice climbers. This region consists of huge chunks of broken ice that look like icebergs. "They're the size of a small city, a few kilometres across, and they have some very steep scarps," Pappalardo says.

Scuba diving isn't quite a winter sport, but Europa would be great for that, too, he adds. The icebergs are thought to have formed over thinner ice sitting above freshwater lakes. And don't forget the vast ocean of water underneath Europa's icy shell.

You'd need some way of venturing a few kilometres below the ice to get to the liquid, though, which remains in that ➤





state because of titanic tidal forces acting on the moon as a result of Jupiter's immense gravitational pull.

Other Jovian moons could play host to winter sports, too. Ganymede and Callisto are each about half-ice, half-rock, and may host oceans deeper than those of Europa or Saturn's moon Enceladus, Pappalardo says. There's so much ice that some of it converts to a higher-density form, allowing it to sink. "Ganymede and Callisto are likely to have an outer shell of ice, like in our freezers, then a layer of water, then high-density ices below that," he says. "So it's kind of an ocean sandwich, with ice above and ice below." Scuba and skating – the perfect holiday combination.

Blue snow and base jumping

Venture a few more hundred million kilometres into space and you'll find excellent wintry terrain on Saturn's moons. Titan's natural lakes are liquid gas, but its surface is covered in ice mountains. Liquid methane and ethane rain onto the surface, which is peppered with ice boulders and ice cobbles. Nearby, the small moon Mimas, made mostly of ice, has a massive impact crater one-third the moon's own diameter. The crater contains a mountain rising 6 kilometres above the floor. "That peak might make

For trails less travelled, look to Enceladus

for some good climbing, although gravity is very low, so it might be cheating," says Pappalardo. That also means you wouldn't have to worry about skiing down – you could simply leap off the top and float down to the surface.

Of all the bodies in our solar system, Saturn's moon Enceladus may be the premier ski resort. In 2011, planetary scientist Paul Schenk scrutinised the plumes there and found a blanket of snow-like material falling onto the surface. The Cassini probe, which has been visiting the Saturn system since 2004, first noted the jets of water vapour, much of which flows towards Saturn to form one of its rings. But Schenk and colleagues noticed a blanket of material on the surface of Enceladus, running in two strips from north to south. The blanket is a bluish colour, and falls at a mind-numbingly slow rate of less than one-thousandth of a millimetre per year, Schenk found. Yet the snow cover is about 100 metres thick in some spots, meaning it must have been snowing for tens of millions of years – that's some ski season.

Enceladus "snowflakes" are much smaller than typical ice crystals on Earth, about 1 or 2 micrometres across,

according to Schenk. That's finer than talcum powder, so anyone hoping to traipse through the blue snow would want to bring some extra-large snowshoes that are better at staying afloat on light, powdery snow. Or you might want to strap on some skis – the ultra-light material is the finest powder any skier could hope for.

Exoplanet extremes

Beyond our solar system, a bevy of exoplanets presents tantalising wintry targets. Most stars in the Milky Way probably have at least a planet or two, if findings from the Kepler Space Telescope and other planet hunters are to be believed. The exoplanet census is full of super-Earths, mini-Neptunes, scorched tiny rocks and gigantic Jupiters, but astronomers are only just beginning to peer at their atmospheres to find out what they are like.

In September, astronomers discovered clear skies and steamy water vapour on a planet about the size of Neptune, located 120 light years from Earth. It is thought to have a rocky core and a mantle of ice.

Plenty of other exoplanets could harbour water in its frozen and liquid forms too. At the moment, imaging the surfaces of other planets is beyond the reach of our telescopes. However, there are more ways astronomers can look out for ice and snow in other solar systems. Last summer, the massive ALMA telescope snapped the first-ever image of a "snow line" in an infant solar system 176 light years distant. On Earth, snow forms when temperatures are cold enough to turn moisture into the white stuff; in solar systems, snow lines form in a similar fashion, where it gets cold enough around young stars. That frigid boundary marks the spot where molecules like carbon dioxide, methane and carbon monoxide freeze and become dust grains, forming the building blocks of planets.

Despite the prevalence of snow, much exoplanet research is centred on finding worlds where water is liquid, not frozen, because it is a prime ingredient in the hunt for life. "But then you could think about water sports," Pappalardo says – and look forward to summer. ■

Rebecca Boyle hopes to reach new heights next season

The real answer to life, the universe and everything

Christopher Kemp discovers the number encoded in our genes

MAXIM MAKUKOV has an idea. It's unorthodox; you might call it "out there". Makukov understands that. He knew he'd have his critics the moment he began to develop it. But it's there in the numbers, he says. And numbers don't lie.

A cosmologist and astrobiologist at the Fesenkov Astrophysical Institute in Almaty, Kazakhstan, Makukov says the numbers reveal that all terrestrial life came from outer space. Not only that, it was planted on Earth by intelligent aliens. Billions of years ago, the planet was barren and lifeless. But then, at some distant and unknowable moment, it was seeded with what Makukov calls an "intelligent-like signal" – a signal that is too orderly and intricate to have occurred randomly.

This signal, he says, is in our genetic code. Highly preserved across cosmological timescales, it has been waiting there, like an encrypted message, for anyone qualified to read it. All of the teeming varieties of life on Earth – from kangaroos and daffodils to albatrosses and us – carry it within them. And now Makukov, along with his mentor, mathematician Vladimir *sh*Cherbak of the al-Farabi Kazakh National University in Almaty, claims to have cracked it. If they are right, the answer to life, the universe and everything is... 37.

The idea that terrestrial life has extraterrestrial origins has a long and sometimes distinguished history. The standard version goes something like this: a primitive alien life form, perhaps

a bacterium, somehow hitches a ride through space aboard an object like a meteoroid, collides with our young planet and seeds it with life. Against innumerable odds, its descendants flourish and spread across Earth.

In 1871, Lord Kelvin hypothesised "that there are countless seed-bearing meteoric stones moving about through space". In his 1908 book *Worlds in the Making*, Nobel laureate Svante Arrhenius named the process "panspermia". As recently as 2009, Stephen Hawking speculated that "life could spread from

planet to planet, or from stellar system to stellar system, carried on meteors".

Prestigious backers notwithstanding, panspermia has not found widespread acceptance, although many biologists accept a weaker version of it. "Most biologists will agree there is a contribution to the origin of life on Earth from cosmic sources," says P.Z. Myers of the University of Minnesota, Morris. "We have lots of organic compounds floating around in space."

Makukov and *sh*Cherbak have taken it further. They're reviving something called "directed panspermia", the hypothesis that life was seeded intentionally by an extraterrestrial intelligence.

The idea goes back to 1973, when Francis Crick published a paper in the planetary sciences journal *Icarus*, at that time edited by Carl Sagan. In it, Crick asked the question: "Could life have started on Earth as a result of infection by microorganisms sent here deliberately by a technological society on another planet, by means of a special long-range unmanned spaceship?"

Extraordinary claims like this require extraordinary evidence. For more than a century, people have been trying to find at least some of that evidence – proof of the existence of sentient aliens. ➤

Code within a code

The genetic code consists of the four DNA bases, A, C, G and T, organised into three-letter "codons". There are 64 codons in total; each specifies one of the 20 amino acids that are used to build proteins, or is a stop signal. Some amino acids are specified by one codon, others by up to six.

The code is subdivided into 16 families; each of the four members within a family start with the same two letters. Half of the families are **whole families** - all four codons code for the same amino acid. The other half are **split families** - the four codons do not all code for the same amino acid

The bulk of this effort – known as SETI, or the search for extraterrestrial intelligence – has involved trying to detect radio signals. But despite almost a century of vigilance, says SETI senior astronomer Seth Shostak, they have heard nothing.

With one possible exception. In 1977, SETI researchers in Ohio picked up a 72-second burst of radio waves that was so close to what they had been looking for that one of the researchers wrote "Wow!" on the readout. Nothing like the Wow! signal has ever been seen since.

"The genetic code is a perfect place to plant a secret message"

The radio silence has inspired some to widen the search. Many have asked: what if the message is here on Earth already? What if we are the message?

In his 2010 book *The Eerie Silence*, Paul Davies, a physicist at Arizona State University, wrote about genomic SETI – the idea that our genome might house a secret message. He was following the physicist George Marx, who in 1979 wrote: "It is possible that a few billion years ago an advanced civilization prepared some sort of message using genetic engineering and sent it to Earth. This extraterrestrial DNA molecule became the starting point of biological evolution."

Makukov and *sh*Cherbak's ideas are in this tradition. But instead of rummaging through DNA, they look to the genetic code, a complex set of rules by which DNA is translated into proteins (see "Code within a code", above right). The genetic code shouldn't be confused with the genome, which is a specific set of genetic instructions for making a fruit fly, say, or a giant redwood. Instead, it specifies how to convert those instructions into proteins.

Unlike genomic DNA, the code is stable. Genomes mutate over time, but the code is passed down the generations without alteration and appears to have remained almost completely unchanged for billions of years.

For that reason, says Makukov, it is the perfect place to plant a message. Billions of years ago, he says, that is precisely what happened.

To test the idea, Makukov and

Whole families

Split families

MM = molecular mass

AMINO ACID

All 20 amino acids specified by the code have a **common core** but different **side chains**. Some of the curious patterns in the code are revealed by the molecular masses of the amino acids and their side chains

MM of the core = 74 (= 2×37)

The molecular masses of the side chains range from 1 (glycine, which has a single hydrogen atom) to 130 (tryptophan)

CODON	AMINO ACID	CODON	AMINO ACID	CODON	AMINO ACID	CODON	AMINO ACID
TTT	Phenylalanine (Phe) (MM 165)	TCT	Serine (Ser) (MM 105)	TAT	Tyrosine (Tyr) (MM 181)	TGT	Cysteine (Cys) (MM 121)
TTC		TCC		TAC		TGC	
TTA	Leucine (Leu) (MM 131)	TCA		TAA	Stop	TGA	Stop
TTG		TCG		TAG	Stop	TGG	Tryptophan (Trp) (MM 204)
CTT	Leucine (Leu) (MM 131)	CCT	Proline (Pro) (MM 115)	CAT	Histidine (His) (MM 155)	CGT	Arginine (Arg) (MM 174)
CTC		CCC		CAC		CGC	
CTA		CCA		CAA	Glutamine (Gln) (MM 146)	CGA	
CTG		CCG		CAG		CGG	
ATT	Isoleucine (Ile) (MM 131)	ACT	Threonine (Thr) (MM 119)	AAT	Asparagine (Asn) (MM 132)	AGT	Serine (Ser) (MM 105)
ATC		ACC		AAC		AGC	
ATA		ACA		AAA	Lysine (Lys) (MM 146)	AGA	Arginine (Arg) (MM 174)
ATG	Methionine (Met) (MM 149)	ACG		AAG		AGG	
GTT	Valine (Val) (MM 117)	GCT	Alanine (Ala) (MM 89)	GAT	Aspartic acid (Asp) (MM 133)	GGT	Glycine (Gly) (MM 75)
GTC		GCC		GAC		GGC	
GTA		GCA		GAA	Glutamic acid (Glu) (MM 147)	GGA	
GTG		GCG		GAG		GGG	

Symmetries of 37

37×1 037	37×2 074	37×3 111	37×4 148	37×5 185	37×6 222	37×7 259	37×8 296	37×9 333
37×10 370	37×11 407	37×12 444	37×13 481	37×14 518	37×15 555	37×16 592	37×17 629	37×18 666
37×19 703	37×20 740	37×21 777	37×22 814	37×23 851	37×24 888	37×25 925	37×26 962	37×27 999

$$\left(\begin{array}{l} 481 \div 37 = 13 = 4+8+1 \\ 629 \div 37 = 17 = 6+2+9 \\ 777 \div 37 = 21 = 7+7+7 \quad \text{etc} \end{array} \right)$$

Rumer's transformation

Whole families can be converted into split families - and vice versa - by switching Ts for Gs and As for Cs

The probability of this happening by chance is extremely small

TT	↔	GG
TG	↔	GT
TA	↔	GC
TC	↔	GA
GG	↔	TT
GT	↔	TG
GA	↔	TC
GC	↔	TA
AA	↔	CC
AT	↔	CG
AG	↔	CT
AC	↔	CA
CC	↔	AA
CT	↔	AG
CG	↔	AT
CA	↔	AC

shCherbak devised a mathematical approach to analyse the code, searching for patterns unlikely to occur at random.

Their arguments are often dense and impenetrable, filled with complex mathematical formulae. But at heart, Makukov says, "it's very simple". The genetic code is like some type of combinatorial puzzle, he says. In other words, once you begin to analyse it, hidden regularities emerge.

"It was clear right away that the code has a non-random structure," says Makukov. "The patterns that we describe are not simply non-random. They have some features that, at least from our point of view, were very hard to ascribe to natural processes."

Exhibit A is Rumer's transformation. In 1966, Soviet mathematician Yuri Rumer pointed out that the genetic code can be divided neatly in half (see "Rumer's transformation", left). One half is the "whole family" codons, in which all four codons with the same two initial letters code for the same amino acid. The AC family, for instance, is "whole" because codons beginning AC code for threonine. On the other are "split family" codons, which don't have this property.

Rumer first noted that there is no good reason why exactly half of the codons should be whole. More profoundly, he also realised that applying a simple rule - swapping T for G, and A for C - converts one half of the code into the other.

That might sound inevitable, but it is not. In 1996, mathematician Olga Zhaksybayeva of the al-Farabi Kazakh National University calculated that the probability of it occurring by chance is 3.09×10^{-32} .

And Rumer's transformation is just one of many patterns and symmetries within the code. Another example: you can create a subset of codons including those with three identical bases (AAA, say) and those with three unique bases (GTC, say). Using a Rumer-type transformation, these 28 codons can be divided into two groups each with a combined total atomic mass of 1665, and a combined "side chain" atomic mass of 703 (see "Transformation #2", left). Both are multiples of the prime number 37, which has interesting mathematical properties of its own (see "Symmetries of 37", opposite).

In fact, 37 recurs frequently in the code.

For example, the mass of the molecular "core" shared by all 20 amino acids is 74, which is 37 doubled. Forget 42...

All in all, the Kazakhs have identified nine patterns in the code, which they spell out in detail in the journal *Icarus* (vol 224, p 228) under the provocative title "The 'Wow! signal' of the terrestrial genetic code".

If you think that all sounds a bit like *The Da Vinci Code for DNA*, you're not alone. "It's flat out numerology," says Myers, who also notes the similarity to the pseudoscience of intelligent design - a comparison Makukov and shCherbak reject. "The hypothesis has nothing to do with intelligent design," they say.

Others are less critical. "It's not, in and of itself, absurd," says David Grinspoon, senior scientist at the Planetary Science Institute and author of *Lonely Planets: The natural philosophy of alien life*. "We're already learning to custom design organisms and we're already learning to send things out into space. If anybody else is out there, the chances are they're not as new at it as we are."

Davies is also quite forgiving. "If you crunch numbers long enough, you'll find patterns in almost anything," he says.

"What is the probability of finding something like this by chance?"

"It was very clear to me at the outset that what this boils down to is an assessment: what is the probability that you might find something like this by chance?"

To that, Makukov and shCherbak have an answer: about 10^{-13} , or 1 in 10 trillion. In October, they published a second paper on the work in *Life Sciences in Space Research* (vol 3, p 10).

As to what - or who - planted the message, Makukov stresses that he doesn't know. "This is speculation," he says. "Maybe they're gone long ago. Maybe they're still alive. I think these are questions for the future."

But on the basic idea, he is adamant. "For the patterns in the code," says Makukov, "the explanation we give, we think is the most plausible." ■

Christopher Kemp is an extraterrestrial based in Grand Rapids, Michigan

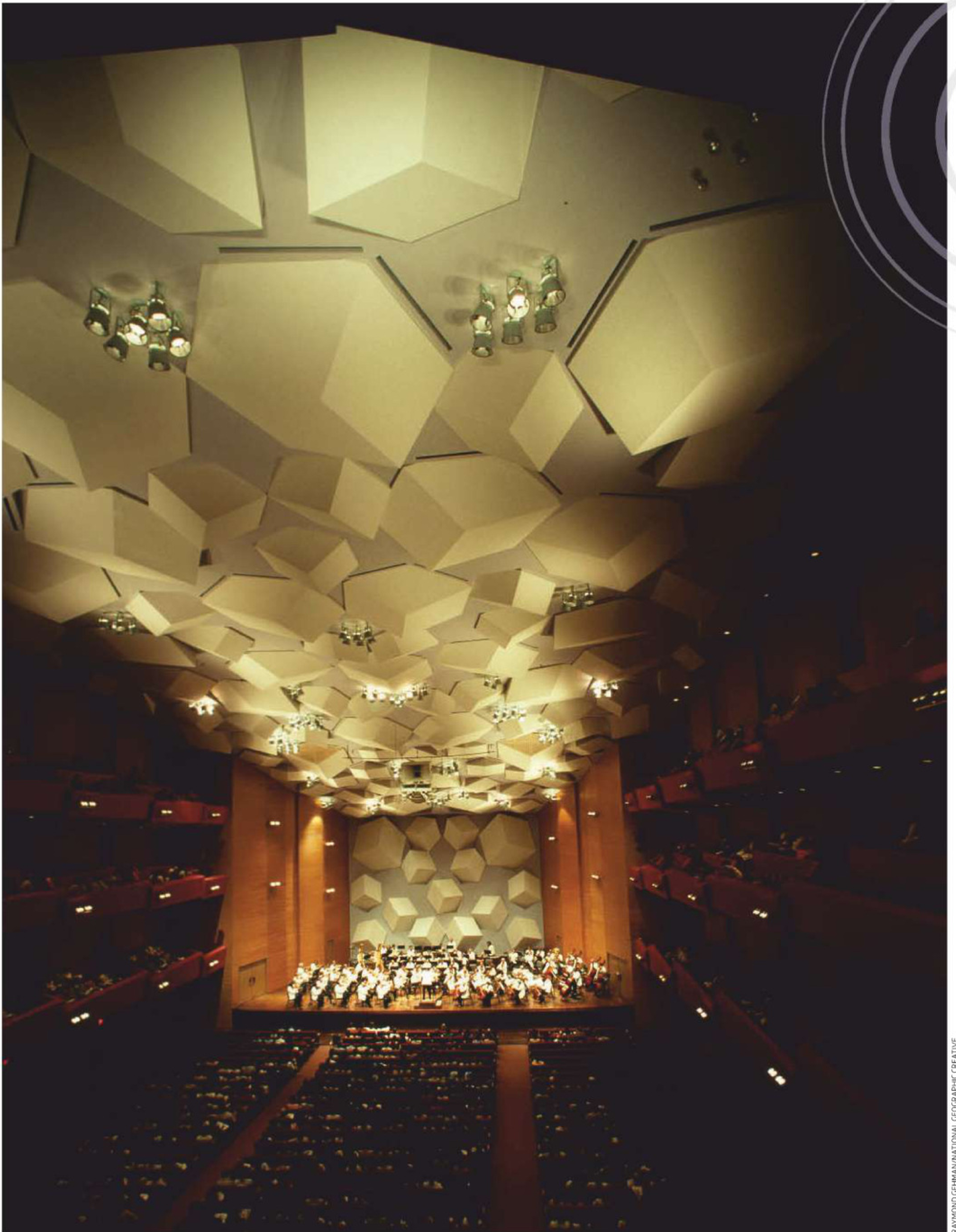
Transformation #2

Another pattern emerges using Rumer's transformation on the subset of codons with either three identical or three different bases

Phe 165	TTT ↔ GGG	Gly 75
Lys 146	AAA ↔ CCC	Pro 115
Ile 131	ATC ↔ CGA	Arg 174
Ser 105	TCA ↔ GAC	Asp 133
His 155	CAT ↔ ACG	Thr 119
Ala 89	GCT ↔ TAG	Stop 0
Leu 131	CTG ↔ AGT	Ser 105
Cys 121	TGC ↔ GTA	Val 117
Stop 0	TGA ↔ GTC	Val 117
Asp 133	GAT ↔ TCG	Ser 105
Met 149	ATG ↔ CGT	Arg 174
Gln 146	CAG ↔ ACT	Thr 119
Ser 105	AGC ↔ CTA	Leu 131
Ala 89	GCA ↔ TAC	Tyr 181

1665 Total molecular mass 1665
(=999 + 666)
703 Total mm of side chains 703
(=19×37) (=19×37)

The pattern is revealed in the combined molecular masses of the amino acids on either side of the transformation



Reverb *erberberb*

Why does music need echo to make it sing?
Sound guru **Trevor Cox** investigates

THE TALL, arched, windowless space has just enough light for me to make out the explicit frescoes of naked bodies and skeletons adorning its walls. But I'm not here in the suburbs of Oslo for the visuals. For people in my line of work, the mausoleum of the Norwegian artist Emanuel Vigeland is most famous for its stunning acoustics.

I burst a balloon, and the bang takes 15 seconds to die away. I sing a note, and another and another, and they hang in the air together as a chord. The effect is spine-tingling. And although this is an extreme example, it illustrates a near-universal truth: we love our sounds with a bit of reverb.

This is, on the face of it, rather odd. Reverberation replaces the clear, unadulterated sounds of our own voices or instruments with something acoustically far more messy. Other musical preferences, such as why we choose consonance over dissonance, are well researched, but the question of why reverb is such an essential part of our musical experience has largely been met with silence. Time to make some noise.

A first whisper of an explanation comes in the acoustic antithesis of Vigeland's mausoleum: the anechoic chamber in my lab at the University of Salford, UK. This is a sonically dead space, where every surface is covered with wedges of sound-absorbing foam. Playing my saxophone there isn't a pleasant experience. Without sound bouncing back off the walls, it all sounds muffled and distant, I hear every mistake of my uneven breathing and nothing smooths the transition from one note to the next.

Listening to a symphony in Vigeland's reverberant mausoleum would hardly be a pleasant experience either, but too little reverb is a complaint made about many performance spaces. London's Royal Festival Hall has attracted particular ire: the star conductor Simon Rattle once said of it that "the will to live slips away in the

first half-hour of rehearsal". Orchestras today often face the challenge of playing music composed for baroque salons in halls filled with a couple of thousand concert goers and their sound-deadening clothing. A long reverberation time – defined as the time it takes for sound to decay by 60 decibels, or a factor of a million in intensity – allows musicians to fill such a large space. On opening in 1951, the Royal Festival Hall's reverberation time was about 1.5 seconds: today, concert-hall architects aim for around 2 seconds.

One functional reason for reverb, then, is to make musicians' lives easier. But electronically added reverb is a common effect in studio-mixed rock and pop recordings. If it were all just about power output, the sound engineer could simply turn the volume knob up to 11. And you can't hush things up by saying reverb helps musicians hear each other and keep in time and tune: even in live pop or rock performances, where musicians tend to monitor each other via headphones or nearby loudspeakers, preferred reverb times are between 0.6 and 1.2 seconds, according to research by acoustician Niels Adelman-Larsen.

Adelman-Larsen is a drummer, and provides one explanation from his experience of performing at a venue in one Danish town. "It's like playing in

front of an aquarium," he says. "We can see the audiences opening their mouths but we don't hear much screaming." That might help to explain our love of reverb as audiences, too. Music-making probably evolved as a collaborative, social experience (see "Beastly beats", page 46); perhaps room reflections enable two-way communication between musicians and audiences, helping us to feel more part of the process even as passive listeners.

Studies of the brain's response to vowel sounds with and without a moderate amount of reverb show it has little influence on the neural encoding of pitch, indicating it doesn't degrade our ability

"A long reverberation time allows musicians to fill a large space"

to follow melody. But it does degrade the encoding of harmonics, indicating a change in perception of timbre. My Salford colleague Bill Davies has floated the idea that reverberated speech acts like natural "susurrating" sounds, like those of a babbling brook, which have been shown to aid recovery from stress. Maybe our innate preference for natural things means we prefer music made less ➤



MICHAEL KAUCORIS

mechanistic by the random elements added by reverberation.

Another key word might be intimacy. Leaving loudness to one side, the emotional impact of music is known to increase the more listeners perceive themselves to be “surrounded” by it – a key effect of reverb that cinema sound engineers and concert-hall designers aim to harness. Research that involved playing listeners in a virtual-reality simulation a variety of sounds including duck quacks, musical chords and pure tones while changing the room size has shown that non-threatening sounds, at least, are perceived to be more pleasant, calmer and safer in smaller rooms with an intimate reverb characteristic.

Nicola Dibben of the University of Sheffield in the UK has used Adele’s Grammy award-winning 2011 hit *Someone Like You* as an example of how reverb is used to create a similar sense of intimacy in studio-mixed pop music. On this track the piano is reproduced quietly, with natural reverberation making it

“The emotional impact of music is increased if we feel surrounded by it”

sound relatively distant. The effect is to bring the singer’s voice closer to the listener, creating a sense that this is an intimate and authentic expression of the singer’s emotions.

This search for aural intimacy is an explanation that chimes with Linda-Ruth Salter, who has co-written a book on architecture and acoustic environments, *Spaces Speak, Are You Listening?* “‘Dry’ sounds are unnatural,” she says. “Every sonic event occurs in a place, and those spatial enclosures modify the sound, including producing reverberation.”

That starts me wondering whether our liking for reverb is innate at all. Could it be a preference we’ve just learned because we rarely experience music without it? I don’t have a final answer yet, but it’s a question worth asking yourself, whether you are listening to festive carols in a cavernous cathedral or bopping to the synthetic sounds at the office party: why do we love acoustic fuzz so much? ■

Trevor Cox’s *Anechoic Night* was not a hit

The eight legs of Christmas

What do you give the spider who has everything, asks [Ed Yong](#)

FOR those of us with clumsy hands, Christmas is a nightmare. It is a time when we encase the gifts that we so thoughtfully bought in an embarrassing mess of crumpled paper and badly placed tape. Perhaps our jobs would be easier if we had eight eyes, eight hands and could extrude our own wrapping paper.

Meet the male nursery web spider. This rather drab looking fellow spends his life in rough grassland and woodland across Europe hunting for insects, which he gives to females in the mating season. When he finds a suitable present, a juicy fly or a mealworm, he paralyses it with his venom. He then carefully wraps the fresh insect in reams of silk, crushing it into a round white ball, before heading off in search of a mate.

Many male insects and spiders woo females with nutritious “nuptial gifts”. There are many benefits to doing so. The gifts advertise a suitor’s qualities as a skilled hunter and forager. They provide nourishment for the mother of their future children. And perhaps most importantly, they distract a potentially cannibalistic female from devouring them instead.

But none of these benefits explain why the nursery web spider wraps its gifts in silk. It certainly isn’t necessary – females will often accept males that give them unwrapped prey. And it isn’t to immobilise the prey as the venom does that. So why bother? It’s only recently that biologists like Trine Bilde from Aarhus University in Denmark have begun to unravel the mystery.

Gift wrapping is just the beginning of a long courtship for a male nursery spider. He walks about in search of a mate, often following lines of silk spun by mature

females. When he finds a female, he rears up, waves his feeler-like palps in the air and presents his gift.

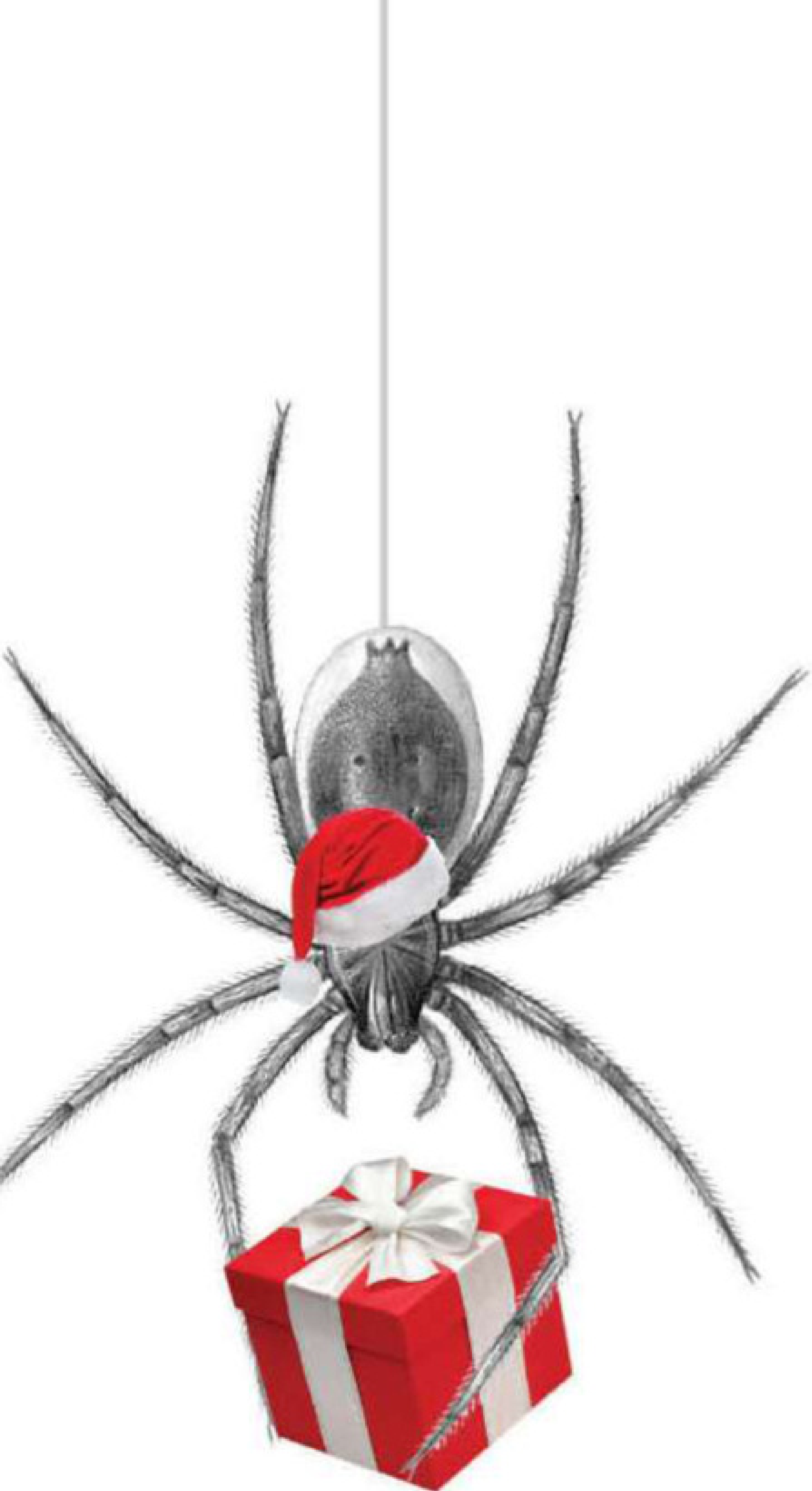
If she is impressed by his efforts, she grabs the parcel and engages in a gentle tug-of-war with him. She will try to steal the gift if possible, but if he resists, she sticks around and starts to eat it. Even then, she can’t unwrap the gift – she can only drool digestive fluids into it and suck up the resulting liquid. While she does, he uses one of his palps to inseminate her, and the other to keep a tight hold of the silk parcel. After an hour, the male finally lets go and the female runs off, taking both his gift and his sperm.

It’s a wrap

Bilde and her team have spent years watching nursery spiders mate in the laboratory. They have found that males with gifts have sex for a blissful 75 minutes compared with just 10 minutes for those that don’t.

Gift wrap means even more time between the sheets. Females take more time to digest a thickly wrapped gift than a poorly wrapped one, giving a male more time to transfer more sperm. The silken strands also give him a better grip upon his gift, which stops the female from simply snatching it and running off. In fact, by simply wrapping their gifts, males can increase the length of their liaisons by another 30 per cent or so.

However, the males aren’t always as generous as they appear to be. Maria Albo at the Clemente Estable Institute for



Biological Research in Uruguay discovered just how deceitful the males can be when she unwrapped the parcels using forceps. "Nobody had really looked at what was inside these gifts," she says.

Albo found that a third of the presents were worthless. Rather than juicy, pristine insects, they contained either plant parts or the empty husks of prey that the male had already eaten. "Normally, you can see the prey exactly as it is," she says. "But when you open the worthless ones, you don't recognise anything."

These worthless gifts have clear advantages for the male. He doesn't waste a meal that he could devour himself, and he might not even need to go to the effort of capturing prey at all. But for the female, it must be like hoping for diamonds and receiving an empty Tiffany box instead. Because all the gifts are wrapped in silk, she can't tell if she's in for riches or disappointment until she starts to feed.

"After 30 minutes, if they realise there is nothing inside, they run away," says Albo. That's still enough time for the male to pump her with thousands of sperm. And yet when Albo and Bilde poured the equivalent of cold water over a mating couple, they found that the females who left early only contained about a third of the sperm of those who finish the job. Fewer of their eggs hatched too.

Nursery spiders aren't the only gift-wrappers. When Albo studied a more obscure species from South America, *Paratrechalea ornata*, she found that the female was attracted to the colour of the wrapping.

She also found that she could turn a male spider into an irresistible catch by dabbing a white spot onto his mouthparts, mimicking the

presence of a white silk parcel. With this subtle beauty spot, females paid more attention to him and accepted him as a partner in half the time and more frequently. That might be because *P. ornata* hunts along the edges of ponds

"It's like hoping for diamonds and receiving an empty Tiffany box"

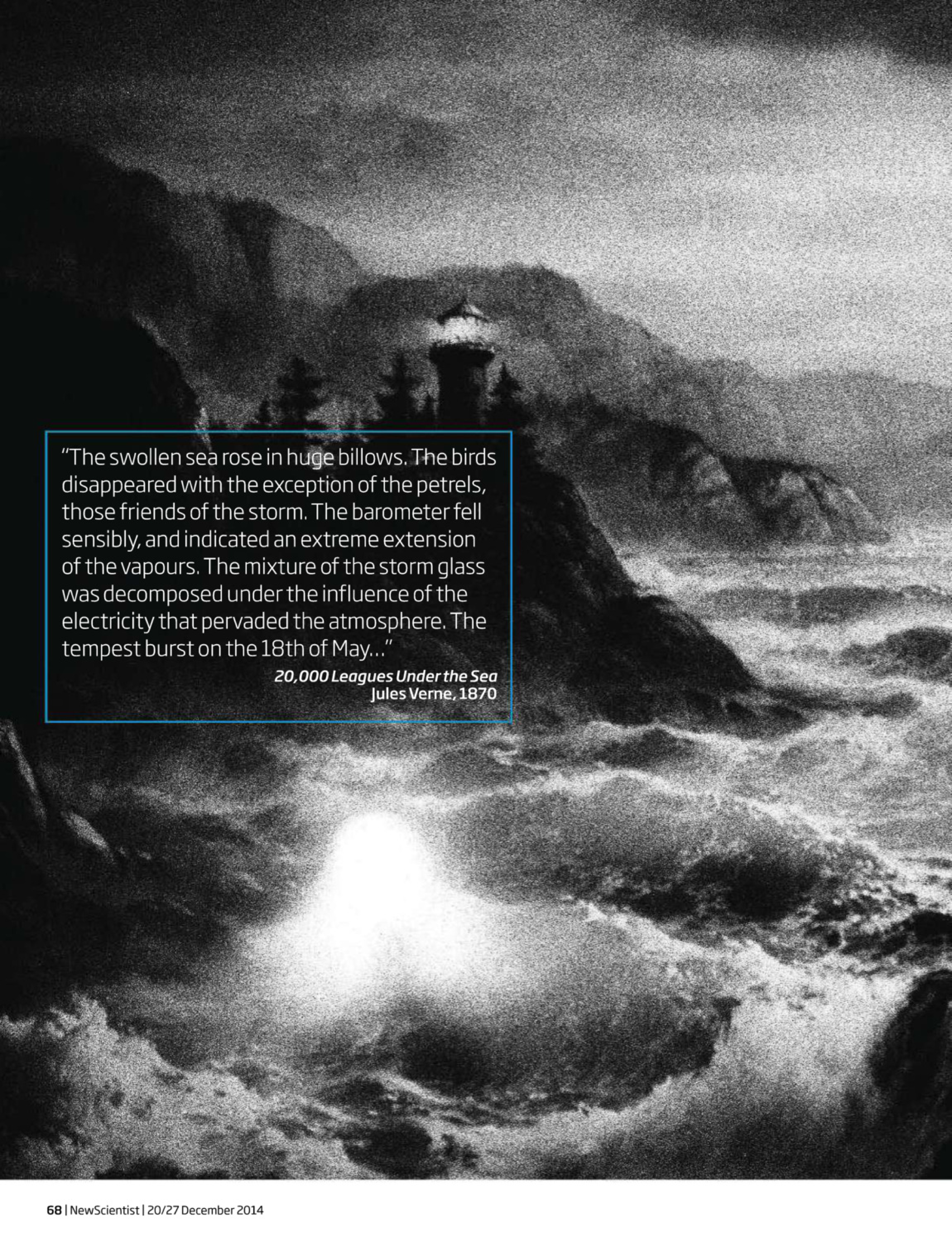
and lakes during dusk and darkness, when white objects are easier to spot from a distance. So if gifts are properly wrapped, they are more likely to lure her in from afar.

Once she gets closer, the gift also acts as a way of showcasing the quality of a male's genes. Albo found that males in rude health are more likely to wrap their prey and wrap them well, producing beautiful, opaque white packages. Weaker males offered sloppy-looking gifts, with bits of black prey visible through meagre strands of silk.

To *P. ornata*, what's on the outside seems to matter more than what's inside. Albo found that 70 per cent of their gifts are empty, meaning deception is the norm. Unlike nursery spiders, however, the females don't seem to care. For this spider, gifts are just silk purses for sows' ears. They neither prefer genuine gifts, nor punish males that offer hollow ones by giving them the heave-ho. It is unclear why. It could be that their habitat is so rife with prey that an extra morsel makes little difference to them. Or they might surreptitiously punish males that offer worthless gifts by getting rid of their sperm later. Either way, in this species, it seems that the ritual of gift-giving is evolving into little more than the exchange of fancy wrapping.

Perhaps it's best you're not a spider. After all, it is what's inside the parcel that really counts. ■

Ed Yong wraps his gifts in paper



"The swollen sea rose in huge billows. The birds disappeared with the exception of the petrels, those friends of the storm. The barometer fell sensibly, and indicated an extreme extension of the vapours. The mixture of the storm glass was decomposed under the influence of the electricity that pervaded the atmosphere. The tempest burst on the 18th of May..."

20,000 Leagues Under the Sea
Jules Verne, 1870

Readers of the storm

Can crystal gazing really forecast the weather, asks [David Hambling](#)

FOR 19th-century mariners, forecasting the weather was a matter of life and death. With few facts to go on, folklore held sway: spouting whales, porpoises entering a harbour, or even lone crows, were all thought to warn of impending storms. Yet vice-admiral Robert Fitzroy of the British Royal Navy knew better.

Captain of HMS Beagle during Charles Darwin's voyage in the 1830s, Fitzroy went on to found the UK's Meteorological Office. By collating data from barometers around the British Isles, he created the world's first weather maps and finally put forecasting on a scientific footing. He even penned a bestseller to explain his ideas: *The Weather Book: A manual of practical meteorology*. Less well-known is his conviction that he could predict the weather by staring into a crystal ball.

Fitzroy's instrument was a "storm glass". Inside it, tiny white crystals would form, grow and disappear, seemingly controlled by some mysterious power. If the glass was clear, Fitzroy claimed, so would the weather be; if its contents turned cloudy, rain was on the way. Crystals at the bottom were a sure sign of frost, while suspended crystals indicated snow. Today this may seem absurd. Many of Fitzroy's contemporaries dismissed his claims as ridiculous. Yet new studies suggest there may be more to this curious instrument than sceptics imagined.

There is certainly nothing magical about the contents of a storm glass: each contains a combination of camphor, potassium nitrate and ammonium chloride, all dissolved in a mix of alcohol and water in precise proportions. Fitzroy wrote that accurate storm glasses could be bought from a shop on old London

Bridge, but there were many imitations "more or less incorrectly made". Storm glasses were around several decades before Fitzroy described them: one version was made in France in the 1780s. Ultimately, though, the origin of their design is lost in time.

According to Fitzroy, the predictive powers of the storm glass arose from its sensitivity to electrostatic forces carried in the wind. He claimed the crystals responded to the direction of the wind, even if the glass was indoors. A north wind produces beautiful crystal growths "like fir, yew, fern leaves or hoar frost", he wrote, while a south wind results in "a soft, melting substance" without crystalline lines and spikes. There were also "very remarkable differences" between an east and a west wind.

Public ridicule

Not surprisingly, weather forecasting as a discipline encouraged doubters. In 1854, the claim that Fitzroy's new Meteorological Office might predict the weather in London a day in advance was met by laughter in parliament. And despite Fitzroy's attempts to publicise the benefits of the storm glass – he dedicated a chapter to it in his book, for instance – few saw it as anything more than a decorative paperweight.

To gain support for his device, Fitzroy wrote to Michael Faraday, claiming that the electrostatic effect had been proved with a "delicate galvanometer". Yet when Faraday responded that he did not see how the glass could be affected by anything other than temperature, Fitzroy dismissed the criticism and suggested that only experienced



Robert Fitzroy strongly believed in the powers of his storm glass

observers could read the glass. He even ensured that both barometers and storm glasses were issued to ports to provide fishermen with alerts of stormy weather.

Then the device came to the attention of Charles Tomlinson, noted scientific investigator and fellow of the Royal Society. Meteorology was a particular interest, and he was vigorous in correcting popular errors and misconceptions. Tomlinson decided to test Fitzroy's claims scientifically.

Over several months in 1862, Tomlinson recorded the response of a storm glass to the weather. He carefully noted how and where crystallisation occurred, and his observations occasionally became lyrical: "lower deposit heaped up towards window like a steep hill hollowed out and covered with beautiful foliage." But he reasoned that all of the phenomena were caused by changes in temperature and nothing else. "It may be fairly concluded that the storm glass acts as a rude kind of thermometer," Tomlinson wrote. That, combined with uncertainty over the exact composition of the camphor mixture, left him recommending that the instrument be abandoned by the Meteorological Office.

Tomlinson carried the day. Barometers remained a fundamental part of weather forecasting, while the storm glass was ➤

all but abandoned. Yet it has not been entirely forgotten.

In 2008, researchers in the UK and Japan took a fresh look at the instrument and suggested, independently, that Tomlinson may have missed something. Measurements made by geologist Allan Mills at the University of Leicester, and a team led by physicist Kazushige Nagashima at Meiji University in Kawasaki, confirmed that the crystals in the glass respond to temperature. Nagashima also proved the crystals were pure camphor and that the height reached by these crystals in the storm glass varies over a larger range than camphor crystals in ethanol or water alone. This suggests that the alchemists who came up with the original recipe managed to optimise the mix to give the most visible effects.

Yet both studies also hint that the storm glass is more than just a simple

thermometer. The chemical cocktail inside seems to have a memory: crystal growth and shape at any one time appears to depend on the pattern of temperature changes that the instrument has experienced. "The appearance of the crystals is completely different, even at the same temperature, if the temperature history is different," says Nagashima. Mills found a similar thing, concluding that a rapid fall in temperature, perhaps associated with an approaching cold front, could conceivably show up as a characteristic crystal form if observed at the right moment. Perhaps Fitzroy's claims for the instrument aren't so unlikely after all.

Other intriguing evidence for the

Are these crystals controlled by atmospheric electricity?

storm glass's sensitivity has emerged thanks to Edward Baranovsky and his colleagues at the Crimean Astrophysical Observatory. They have gathered data daily from separate storm glasses at their lab near Nauchny in Ukraine since 1995. They suggest that these instruments behave in similar ways: the vertical height of the crystals generally increased and decreased simultaneously during this time. More surprising, however, is their claim that these patterns were reproduced in another storm glass 2500 kilometres to the east, in Chelyabinsk, Russia (*Izvestiya, Atmospheric and Oceanic Physics*, vol 46, p 925).

It's unlikely that local weather conditions at these sites follow the same patterns. Rather, Baranovsky suggests that the storm glasses are picking up some regional or global atmospheric phenomenon – perhaps weak electromagnetic fields generated in the ionosphere – that influences the water in the instruments and so alters the growth of the crystals. It is an uncanny echo of Fitzroy's own explanation.

Nagashima, who has studied camphor crystals for 12 years, admits that understanding the complex chemistry

"The chemical cocktail in the glass seems to have a memory"

in the storm glass is hugely challenging: "I enjoy unravelling the mystery," he says. However he is sceptical of any electromagnetic influence.

But don't dismiss the idea just yet, says Nicholas Blagden, an expert in crystal formation and growth at the University of Lincoln, UK. These processes are still a bit of a mystery, he says, and the literature is riddled with reports of substances that crystallise one day and then stop. "People have talked about the effect of magnetic fields on crystallising calcium carbonate. But it wouldn't be in my top five of possible influences."

For now, it seems there's just one firm forecast: to have any hope of predicting weather with Fitzroy's jar, we'll need to crack its chemical secrets first. ■

David Hambling is taking an umbrella just in case



Pearls of wisdom

Is there any scientific truth behind common sayings, asks [Richard Webb](#)

EARLY TO BED, EARLY TO RISE, MAKES A MAN HEALTHY, WEALTHY AND WISE

Answering that would involve tracking how our habits influence our development over many years. Luckily, the US National Longitudinal Study of Adolescent to Adult Health has been doing just that with some 15,000 young people since 1994. In the fourth wave of interviews in 2008, with respondents aged between 24 and 34, self-confessed night owls tended to have higher IQs - and higher-paid jobs. Satoshi Kanazawa of the London School of Economics suggests a reverse logic: the more intelligent you are, the more likely you are to adopt novel evolutionary practices such as being up at the witching hour. So while the jury remains out on the healthy part, if you want to make a packet, take a mallet to that alarm clock.

TOO MANY COOKS SPOIL THE BROTH

Seems so. It has been shown, for instance, that countries where the highest executive bodies are smaller tend to score better on measures of economic and social development (*New Scientist*, 10 January 2009, p 38). The latest example comes from Paola Aversa of the Cass Business School in London. Looking at every Formula 1 race in the 30 years until 2010, she found teams with two star drivers fare worse than those with a clear top dog and a second fiddle.

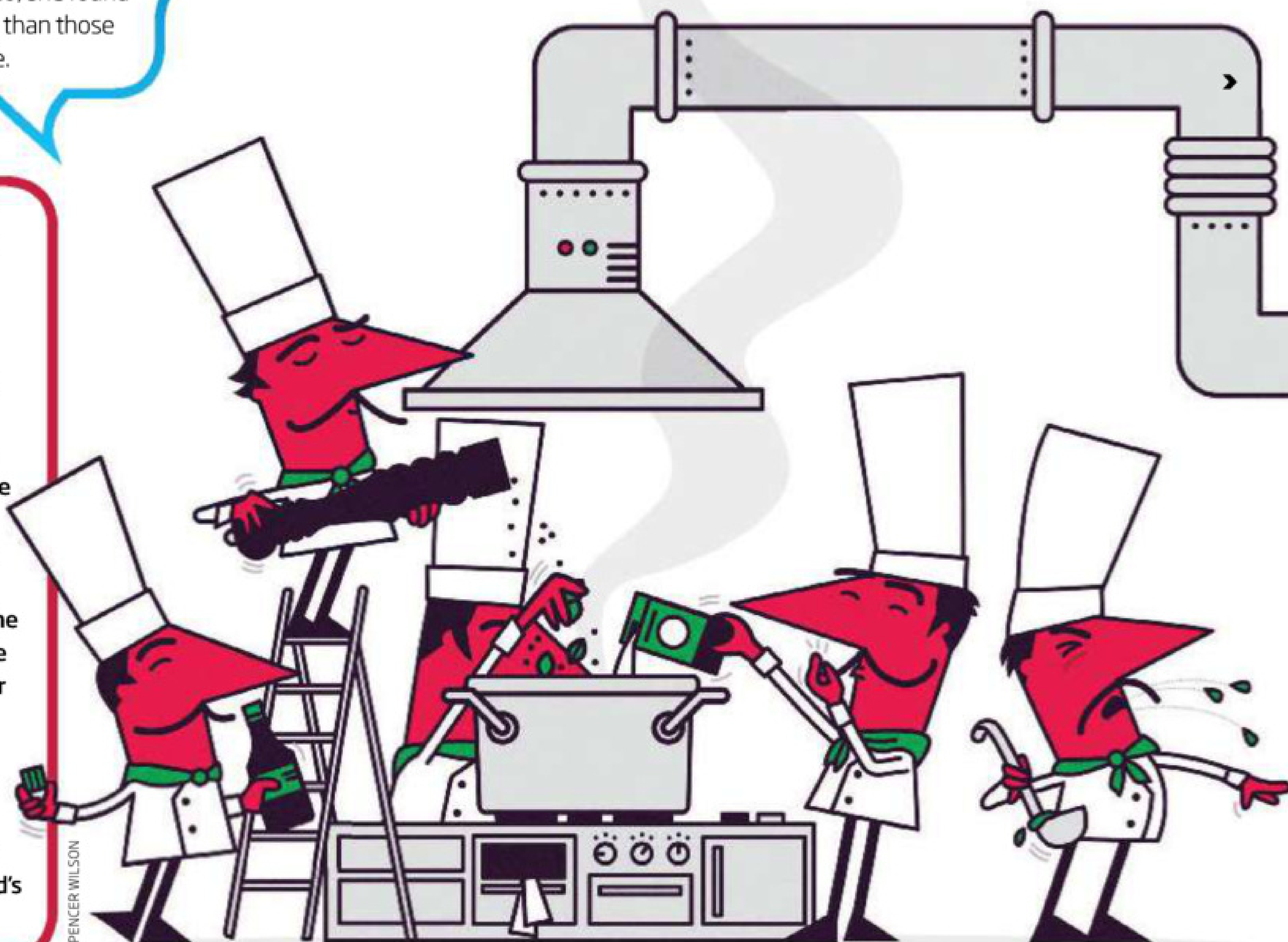
RED SKY AT NIGHT, SHEPHERD'S DELIGHT

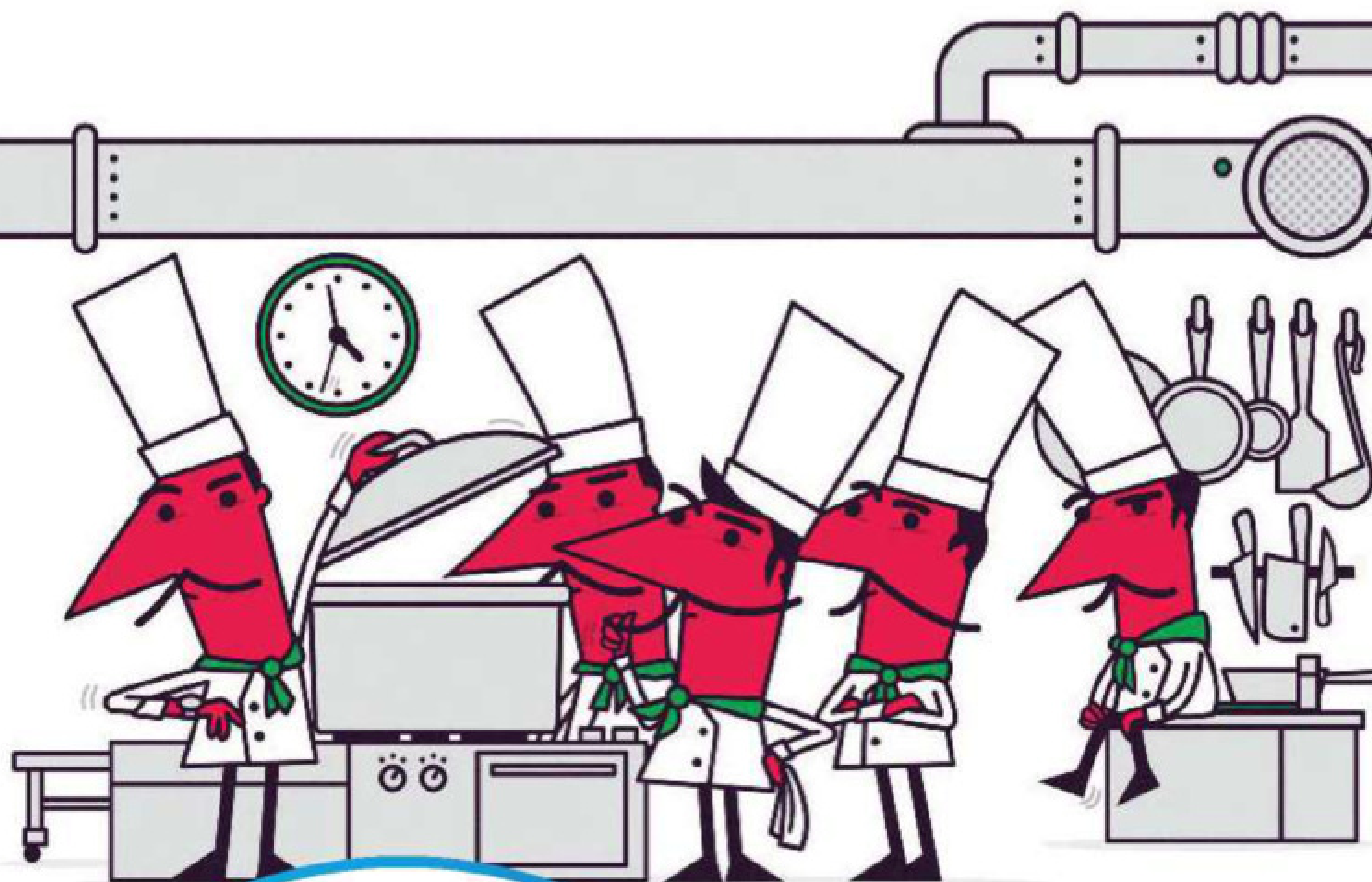
Or sailor's delight, as another common version has it. Either way, there is a grain of truth in the saying. According to the UK's Met Office, it is most reliable in places such as Britain, where the weather tends to come from the west. High pressure systems - an augury of good weather - trap dust particles in the atmosphere that scatter and attenuate bluish wavelengths of light, making for a rosy hue from the setting sun.

If the red light comes from the rising sun in the east, meanwhile, the high-pressure system has already passed over you, with wetter, windier conditions on the way - and a shepherd's or sailor's warning.

NO TIME LIKE THE PRESENT

We might feel as if we are perpetually trapped in the present, unable to ever reach the future or return to the past. Poppycock, say physicists. Since Einstein, time and space have been bound together in one combined space-time. In this picture, all of time just "is" and there's no distinctive "now" any more than there is an objectively defined "here" (*New Scientist*, 2 November 2013, p 34). In the words of the moustachioed meister himself, "People like us, who believe in physics, know that the distinction between past, present and future is only a stubbornly persistent illusion." That's you told.





THE EARLY BIRD CATCHES THE WORM

True, if the work of ornithologists Damien Farine and Stephen Lang of the University of Oxford is anything to go by. Following the foraging strategies of tits in a nearby woodland, they found that most food was discovered in the very early hours of the day. Oddly, though, birds often returned to fully exploit their finds later – perhaps, the researchers speculate, because otherwise the early bird-eater might catch the early bird stuffed full of worms.

A WATCHED POT NEVER BOILS

True – as long as it's a quantum pot. Objects governed by quantum laws lead generally shadowy lives, and according to the most popular interpretation of this most bamboozling theory are only usually nudged to take on a definitive guise by observing them. One odd consequence, described by mathematician Alan Turing in 1954, is the quantum Zeno effect: observe an unstable quantum particle often enough and you can actually prevent it from ever evolving. First confirmed experimentally in ions trapped in a magnetic field in 1990, the effect could be used to tame the annoyingly unruly “qubits” of future super-powerful quantum computers.

FAMILIARITY BREEDS CONTEMPT

Family get-togethers can be as full of needles as the carpet under the Christmas tree. But do we really treat people worse the better we know them? Convincing proof is thin on the ground, perhaps because we tend to act differently when men and women with clipboards are watching us. In 2007, Michael Norton of Harvard Business School and his colleagues did claim proof with evidence that the more information we are fed about a hypothetical person, the higher the chance that we will dislike them. This only unleashed a lively spat with rival researchers about whether that really got to the nub of the question. So perhaps pretend you don't know your nearest and dearest, and see if that makes things any better.

TWO WRONGS DON'T MAKE A RIGHT

The true value of a double negative divides logicians and linguists. Back in 2008, quantum-information researchers found their own answer of sorts. They were experimenting with sending quantum-encoded signals down channels so noisy that the signals were obliterated in transit. Sending the same signal simultaneously down two such channels, you might expect the same thing to happen twice. In fact, the signal arrived crystal clear – like seeing perfectly despite being blind in both eyes. As so often with quantum physics, the aim isn't to understand, just to accept. “Shut up and calculate!”, as the discipline's practitioners are wont to say.

YOU CAN'T TEACH AN OLD DOG NEW TRICKS

Not so: the past few years have seen a sea change in our estimations of what the adult human brain can do. Any decline in our learning abilities with age would seem to have more to do with the fact that we have a lot more to think about rather than our capabilities (*New Scientist*, 25 May 2013, p 32).

As for Bouncer, it might look as if he's intent on imitating a fireside rug for the rest of his days, but Lisa Wallis of the Clever Dog Lab at the Messerli Research Institute in Vienna, Austria, and her colleagues have shown that attention span and sensorimotor abilities actually peak in canine middle age – and suggest it's a similar story in humans.

There is life in the old dog yet.

Richard Webb's fine words butter no parsnips

Eat yourself drunk

Steamed, toasted, pickled or stewed, there's more than one way to end up under the table, as [Graham Lawton](#) discovers



I LOVE cooking with wine. Sometimes I even put it in the food.

Ah, the old ones are the best. But here's an oldie that is well past its sell-by date: if you cook with wine, all the alcohol is "burned off" by the heat.

When I started telling people about my plan to see if I could eat myself drunk, I heard this piece of kitchen folklore again and again. And no wonder: it seems so plausible. The boiling point of ethanol is about 78.5 °C, significantly lower than the boiling point of, say, a casserole. So if you add wine to a hot pan, the alcohol evaporates.

Not so. In 1992, a team of food scientists at the University of Idaho put this old chestnut to the test. They created several different booze-laden recipes, each with a different method of adding alcohol, and tested how much was left at the end. The answer ranged from "not much" to "most of it" – but all the recipes, including a casserole cooked for two-and-a-half hours, retained some alcohol.

This got me thinking: is it possible to get drunk only by eating things? If I ate a helping of, say, coq au vin followed by peaches in brandy, could I get pie-eyed? Not falling-down drunk, but legally drunk, which in England means being over the drink-drive limit of 80 milligrams of alcohol per 100 millilitres of blood, or a blood alcohol concentration of 0.08 per cent.

Herein lies the serious side of my experiment. If cooked foods retain alcohol, people need to be careful – especially around Christmas. If a helping of casserole or a slice of Christmas cake ➤



contains even a few millilitres of alcohol, then eating it may be enough to push a careful but not totally abstemious driver onto the wrong side of the law.

The first thing I had to find out was how much I needed to drink to get over the limit. So I bought a breathalyser and set to work.

For my first attempt I went to the pub, drank a pint of lager (5 per cent alcohol by volume), went back to my desk and waited. My breathalyser advises waiting at least 30 minutes before using it so the alcohol has cleared from your mouth, or else it upsets the reading. Half an hour later, I tested myself; the reading was 0.07 per cent, just below the limit.

The next day, I bought some beers on my way home and drank one before dinner. Half an hour later I breathalysed

Tastes dry? Perhaps, but this innocent looking meal can get you drunk

myself and found I was unfit to drive, with a blood alcohol level of 0.09 per cent – a bit of a surprise because I had drunk less than the day before. But other circumstances, such as food consumption, the environment in which you drink and even your mood can influence the rate at which the alcohol is absorbed. I drank another couple of beers just to make sure, but forgot to test myself again because I was watching reruns of *Man v. Food*.

In the end, I calculated it would take around 25 millilitres of alcohol (2.5 units) in liquid format to push me over the drink-drive limit. Would that also hold

MENU

STARTER: Chorizo flambéed in brandy

Alcohol added: 45 ml brandy, 36% ABV

Method: flambé

Alcohol retention: 75 per cent

Ethanol consumed: 12.15 ml

MAIN: Fish in white wine

Alcohol added: 180 ml wine, 12% ABV

Method: simmer, 30 minutes

Alcohol retention: 35 per cent

Ethanol consumed: 7.56 ml

DESSERT: Sherry trifle with syllabub topping

Alcohol added: 275 ml sherry, 17% ABV

45 ml brandy, 36% ABV

Method: no heat, refrigerated

Alcohol retention: 70 per cent

Ethanol consumed: approx 6 ml per portion

DESSERT 2: Long Island Iced Tea cake

Alcohol added: 255 ml spirits, 40% ABV

Method: baked, 30 mins

Alcohol retention: 35 per cent

Ethanol consumed: approx 4.5 ml per slice

EMERGENCY LIQUEUR CHOCOLATES

Approximately 0.06 ml alcohol per chocolate

for alcohol in food?

It quickly became clear that I could do it the easy way or the hard way. The easy way would involve a lunch of vodka jelly, liqueur chocolates and other things that are really just booze masquerading as food. The hard way would involve cooking, and then eating, a lot of food with quite low levels of alcohol in it. I chose the hard way.

My colleagues, who I turned to for menu suggestions, weren't much help. Most said "don't bother, the alcohol will all have burned off" (where have you been?). Lots of them came up with items on the banned list. Vodka gazpacho sounded promising until I realised that it is basically a Bloody Mary and hence not food. One colleague told me about a Jamaican cake called "black cake" that is apparently so potent it can knock out a horse, but it took too long to make.

And so I asked Google. Google was really helpful. It led me, among other things, to a study carried out in 2011 that tested various dishes for alcohol retention and, helpfully, included a recipe for fish simmered in white wine. My search also alerted me to the idea of flambéing chorizo, and led to a recipe for a cake so boozy that you could probably use it as an incendiary device.

ALCOHOL RETAINED IN COOKED FOOD

85% If alcohol is added to boiling liquid then taken off heat

75% Flambéed

70% No heat, stored overnight

Alcohol stirred into mixture then baked/simmered for:

15 minutes = 40%

30 minutes = 35%

1 hour = 25%

1.5 hours = 20%

2 hours = 10%

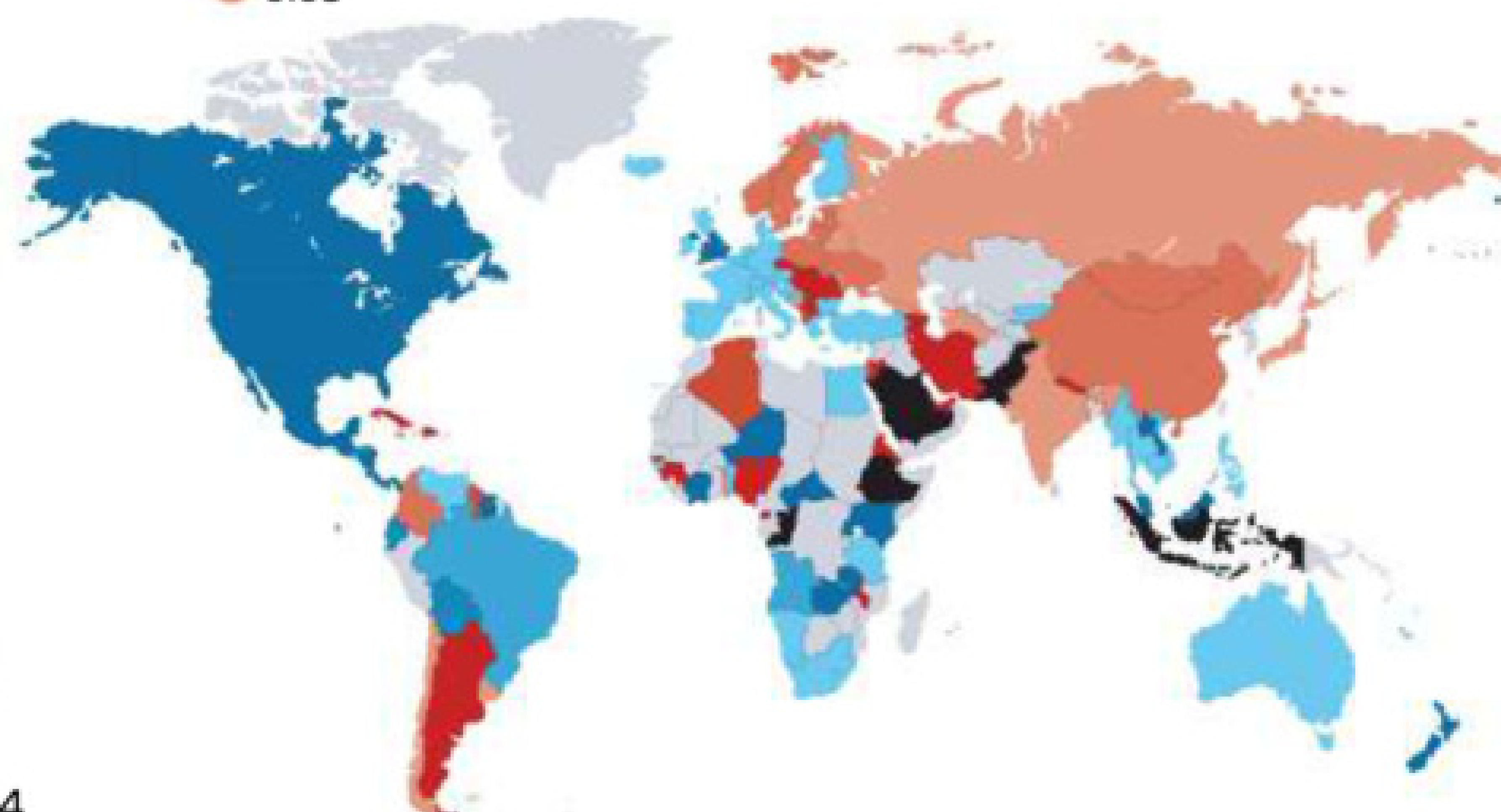
2.5 hours = 5%

One for the road

Drink-drive limits for ordinary motorists around the world

Blood alcohol by volume (per cent)

- 0.08
- 0.07
- 0.06
- 0.05
- 0.04
- 0.03
- 0.02
- 0.01
- zero
- No set limit
- No data



The final menu (opposite) was designed to deliver about 30 millilitres of alcohol; I was confident of making it over the line as long as I could manage to eat everything – though I bought a box of liqueur chocolates just in case.

Did I make it? Yes and no. The starter instantly tipped me over the drink-drive limit. That fits with the surprising finding that one of the least efficient methods of getting rid of ethanol is flambéing, with 75 per cent left after the flames go out. Although the potent effect may also have been because I breathalysed myself too soon, when my mouth was still awash with brandy.

After the main course I was still over the limit, though less so. According to the fish study, cooking the dish this way retains around 30 per cent of the alcohol. That's because alcohol forms what is called an azeotropic mixture with water, in which the vapour has the same alcohol/water ratio as the liquid. In other words, boiling the mixture doesn't change the ratio – so it is impossible to boil the alcohol off completely. The dish should have added to my previous tipsiness, but perhaps the potatoes washed some of the brandy out of my mouth.

The trifle was another instant lawbreaker, pushing the breathalyser over its detection threshold (which was more than twice the drink-drive limit) and the cake – which in true seasonal style I forced down despite being full – kept it there. I'm not sure whether that was down to alcohol in my mouth or my bloodstream. But I felt distinctly drunk and would not have driven.

I even ate one of the emergency chocolates. OK, two.

Half an hour after finishing, I was hovering around the limit. After an hour I was safely back under it (though I would still have been unfit to drive in many countries because the UK has some of the laxest drink-drive laws in the world). But I think my point has been made: even if you don't drink any alcohol, food can push you over the legal limit. So if you do have a drink and are expecting to drive home, be careful what you eat. And next time somebody tells you that cooking with wine burns the alcohol off, tell them about the man who ate himself pissed. ■

Graham Lawton is a trifle drunk



DOWN

1. Silicon word whizz was Oprah guru, by the sound of it (2,4)

Can a computer set a decent crossword?

You're about to find out, says [Michael Brooks](#)

MATTHEW GINSBERG can't help feeling a little sorry for his crossword-solving computer program. He points to a recent *New York Times* clue: "Food or drink dispensers". The answer? "MachinesV". "How is a computer meant to figure that out?" Ginsberg asks. "It's not fair."

If you're stuck: it's "v ending machines", or vending machines. Plenty of people struggle with this more whimsical sort of crossword clue, which can combine

general knowledge, word play and cultural references with a generous dose of lateral thinking. A silicon processor, armed only with remorseless logic, seems even less well equipped. It's all the more surprising, then, that Dr Fill, Ginsberg's baby, is now better at *New York Times* crosswords than all but the top human solvers. Remember the hullabaloo when IBM's Deep Blue beat the reigning chess world champion, Garry Kasparov, in 1997? Looks like the crossword could be ➤

the new chessboard.

Computers began to hook themselves up to the crossword grid a while back. Fitting words into such a grid is a classic example of a constraint satisfaction problem, something that computers excel at. The constraints are that the words must exist (generally, which is why that *New York Times* clue is a bit of a cheat if you ask me) and no two letters in the grid should clash. Give a computer access to a large enough dictionary, and it can crunch through the possibilities far faster than a human to find an optimal solution; indeed, many crossword compilers now use silicon brains to generate an answer grid to which they can write the clues. Give the computer a thesaurus too and it will stand a good chance of solving “straight” or “quick” crosswords that consist purely of redefinitions of the words in the grid.

Solving crosswords of the more cryptic type is a different story, however. The clues here have both a surface reading and another, more devious reading, making cracking them a battle of wits with whoever created it. That is a problem for any artificial intelligence. “You can’t write a program to get into somebody’s mind,” says William Tunstall-Pedoe. He built Evi, a “knowledge engine” that aims to give answers to naturally posed questions, which was recently bought by Amazon. He has also written a crossword clue solver. “It makes hypotheses about what bits of the clues can mean, and then it tries to get those hypotheses to produce an answer that fits.”

British-style crossword clues are often particularly fiendish, with the cryptic element set at maximum, so I fed an example from the London *Times* to one of Tunstall-Pedoe’s crossword solvers, available online at crosswordtools.com: “Grand native of Belgrade going about on horseback (6)”. I got back five words assessed as having a more than 1 per cent chance of fitting the clue: Creole (32%), hoggin (26%), direct (15%), honest (15%) and superb (11%).

It gave me its working out. The explanation for favouring “Creole” included the phrases “I am not sure about the ‘grand’ bit”, and “‘horseback’ becomes ‘ole’”, the latter qualified apologetically with “I can’t justify this – if you can you should give a lot more credence to this answer”. At least that’s honest, and

1	2	3	4	5		6	7	8	9		10	11	12	13
14						15					16			
17						18					19			
20					21					22				
23							24							
			25			26			27		28	29	30	31
32	33	34			35			36		37				
38				39					40					
41						42					43			
44					45		46			47				
				48		49			50			51	52	53
54	55	56	57					58						
59					60					61				
62					63					64				
65					66					67				

Note Dr Fill uses US spellings and is generally influenced by an upbringing on that side of the pond

ACROSS

- 1. Most celebrated (1, 4)
- 6. 20’s suppliers (4)
- 10. Element in Einstein’s formula (4)
- 14. Noted clergyman (5)
- 15. Unit of loudness (4)
- 16. Graphic beginning (4)
- 17. Peaks (5)
- 18. Prefix with market (4)
- 19. Sigmund’s sword (4)
- 20. It’s legal in Massachusetts (4, 3, 8)
- 23. Timorous (6)
- 24. Data measure (4)

- 25. Tend (3, 2)
- 27. Native-borne Israelis (6)
- 32. The skinny (4)
- 35. Type of skirt (4)
- 37. Nonsense, slangily (5)
- 38. Not-so-great explanation (4, 5, 6)
- 41. Just around yon corner (5)
- 42. “Groenlandia”, e.g. (4)
- 43. ____ to the city (1, 3)
- 44. Slays (4, 2)
- 46. Wants (5)
- 48. Oz dog (4)
- 50. Kind of ax or ship (6)

- 54. Video game featuring Gloom-shrooms, Melon-pults and Cherry Bombs (6, 2, 7)
- 59. Grade (4)
- 60. Cruising (4)
- 61. Exuviates (4)
- 62. Confess (4)
- 63. Pastures (4)
- 64. Where Rushdie’s roots are (5)
- 65. Vitamin A sources (4)
- 66. Famous last words (2, 2)
- 67. Itsy-bitsy (5)

DOWN

1. Women with ____ (1, 4)
2. 70's Renault (2, 3)
3. Ashlee Simpson album with the song "Boyfriend" (1, 2, 2)
4. Convertibles that extend (5, 5)
5. Red Sox Nation's anthem (6)
6. Culmination (4)
7. Display contempt for (5, 4, 4, 2)
8. Brightly colored eel (5)
9. Two jiggers (6)
10. Men who made a star trek (4)
11. Subtle quality (4)
12. Prenuptials party (4)
13. Not all (4)
21. Anasarca (5)
22. Extend to (5)
26. Kon-____, Heyerdahl's boat (4)
28. Sternum (10)
29. Chess castle (4)
30. Middle East port (4)
31. Vodka sold in blue bottles (4)
32. "If ____ My Way," 1913 Classic (1, 3)
33. One-billionth: Comb. form (4)
34. Scamper away (4)
36. Unemployed (4)
39. Actress Eklund (5)
40. Cardio option (5)
45. Key on a cash register (2, 4)
47. "Nerts!" (6)
49. Show case? (2, 3)
51. Diacritical mark (5)
52. Admit (3, 2)
53. Test type (5)
54. Say the rosary (4)
55. Pumice (4)
56. Energy source (4)
57. Fresh reports (4)
58. Silents star Pitts (4)

Full answers to the crossword will appear in our 17 January 2015 issue. A set of *New Scientist* books will go to the first correct entry drawn out of the hat on 6 January. Details of how to enter and full terms and conditions at bit.ly/NSxword (free registration necessary)

gave me some candidate words, one of which was right: more than the organic intelligence inside my skull supplied without prompting. (If this really isn't your bag: a native of Belgrade is a Serb, which in the clue "goes around" (surrounds) the word up, which can be vaguely associated with being on horseback, forming a word in sum total with the meaning "grand": superb.)

The ideal is for human and machine to work together, apparently. "In combination with a person, it's hugely helpful," Tunstall-Pedoe says. Perhaps that person shouldn't be me. The more clues I ask the solver to solve, the more confusing things become. The favourite answers don't mesh together. Soon the back page of my copy of *The Times* is a mess.

Compared with this piecemeal approach, Dr Fill represents artificial intelligence's all-out assault on the crossword grid. Back in 1976, Ginsberg, whose speciality is optimisation mathematics, wrote what he thinks was the first software to construct crosswords. He didn't start thinking seriously about it until a decade or so

"It is the first decent puzzle made almost entirely by computer"

later, when a friend had a couple of puzzles accepted for publication in *The New York Times*.

These things take time: it wasn't until 2011 that Dr Fill debuted in the American Crossword Puzzle Tournament, a highlight of the US puzzling calendar. "It was very good almost immediately, and has been inching up the scales ever since," Ginsberg says.

Dr Fill's secret is knowledge: it has a huge database of 6 million crossword clues and answers. It searches these entries for correlations with the clues in a given puzzle, then tries them all out in the grid to see if they fit together. If they don't, it starts again and tries a different combination (arxiv.org/abs/1401.4597). It's a bit like Netflix trying to predict what movies you are going to like, Ginsberg says: you just elicit patterns from information without really trying to understand it. "Dr Fill is just one more

application of big data," he says.

It seems rather prosaic, and the brute force approach has its limitations. Although it is among the top 100 solvers based on speed and accuracy, Dr Fill has probably got as good as it can, says Ginsberg. Anything more would need a more subtle approach to AI.

Time, then, to set Dr Fill a new challenge: writing a cryptic crossword from scratch. This is a really tough nut to crack. Creating a phrase that reads well on the surface, but also encodes an answer that is almost unrelated to that surface meaning, is incredibly difficult. "It requires a deep understanding of language and the real world to do that well," says Tunstall-Pedoe. Indeed, he reckons the problem provides a good measure of our AI capabilities. "There could be a Turing test for cryptic clues set by a computer: can you distinguish between a human-set one and a computer-set one?"

Ginsberg agrees. Writing such clues requires the kind of contextual understanding that lets us know what people mean when they say, "This is the room where the President holds his balls and dances", he says. (Back when he was a college professor, Ginsberg wasn't allowed to use this example in the AI textbook he was writing; he had to settle for Groucho Marx's "Time flies like an arrow, fruit flies like a banana".)

No wonder both Tunstall-Pedoe and Ginsberg declined our invitation to unleash their AIs on creating a British-style cryptic crossword – that might be something for our centenary issue in 40 or so years' time. But Ginsberg did agree to program Dr Fill to generate a *New York Times*-style crossword. You'll find it opposite. The clues are not the twisted type, but they do sometimes require a bit of lateral thinking.

If you find it easy to solve, that's instructive: it took several iterations to set and Dr Fill had to be given new instructions once when two very similar words popped up in the grid. Still, says Ginsberg, "It's the first decent puzzle made almost entirely by a computer."

So sit back and pit your intelligence against the artificial version. May the best player win! ■

Michael Brooks is an archangel in charge of babbling streams (7, 6)

Animal rights and wrongs

Forget the idea of solidarity with animals, they'll still eat you, says **Adam Roberts**

MOST of us agree that gratuitous cruelty to animals is wrong. But why? Is it because people who are cruel to animals are more likely to be cruel to human beings? Or is it because the animals have an absolute right not to suffer? Then again, are there more complex arguments about rights and responsibilities to be made?

It's fascinating territory to judge by three books published this year. Those who doubt the circumstances implicit in the second question above should taking a detour through *The Link Between Animal Abuse and Human Violence*, which caused a minor storm in 2009.

Edited by theologian Andrew Linzey, the essays demonstrate statistically that those who abuse animals for fun are more likely to abuse other human beings. This came as a shock to many, but it is commonsense really. Think of the popular notion of the serial killer who learns his ghastly craft by torturing pets, not to mention the everyday desensitisation to animal suffering caused by killing and eating them, even with the moral proviso of humane farming.

One of the essays introduces the notion of "animal abuse denial", a phrase coined, presumably, on the model of "Holocaust deniers". Most of us are deniers: we have an inkling that, for example, the products we buy and our food choices come at some costs to the animals, but we push such reality aside.

This poses larger questions, though. The vast populations of cows, pigs and chickens exist only

because we raise them for food. A world of vegetarians would be a world without such animals because there would be no economic reason to raise them. The claim that non-existence is morally preferable to one that ends in premature abattoir death seems, at the least, debatable.

Coming up to date, Stephen Moore's collection *Divinanimality* goes straight to the intrinsic worth argument – on spiritual

"We have an inkling that our food choices come at some costs to the animals, but we push such reality aside"

and religious grounds. The title (from the French philosopher Jacques Derrida) sees animals collectively as "radically other" in ways akin to the "radical otherness" of God, so as to position humans and animals within a shared sphere of mutual respect and care.

That the Christian God is incarnated as a human, and not an animal as in the Egyptian, Sumerian and Greek traditions, doesn't seem to trouble the exclusively Christian contributors to *Divinanimality*. A Muslim or Jewish perspective might have helpfully broadened the case.

David Naguib Pellow also takes no prisoners in his energetically written polemic *Total Liberation*. This is a call for direct action. "All oppression is linked!" he rants. "Never apologise for your rage!" and "Liberation from government and market!" Pellow's aim (the title of his second chapter) is



FABRICE PICARD/AGENCE VU

READ ON...

Divinanimality: Animal theory, creaturely theology by Stephen D. Moore, Fordham University Press, \$33/£22.46

Total Liberation: The power and promise of animal rights and the radical earth movement by David Naguib Pellow, University of Minnesota Press, \$22.95/£14.21

Interspecies Ethics by Cynthia Willett, Columbia University Press, \$30/£20.50

nothing less than: "Justice for the Earth and all its animals", and the book is as broad-brush as the agitprop slogans suggest.

Rather more meditative, but still polemical, is *Interspecies Ethics* by Cynthia Willett, which styles the behaviour of young African and Indian elephants as an insurgency against human oppression. Adolescent males, she writes, alone or in gangs, "have been attacking villages and ploughing under swathes of crops in retaliation for the murder of their families and the destruction



Dilemma: is it morally better not to exist than to face early death?

of their tribal land". And this is no figure of speech. "Animals are like us," she insists. We must "secure animal rights ... support cross-species solidarity with animal co-workers and co-inhabitants of interspecies communities".

Unlike these authors, I am more cautious, tending to clap the phrase "animal rights" in scare quotes. That's because I'm committed to a model of rights that is simultaneously inalienable

and defined by their reciprocal relationship to social duties. Accordingly, I'm not sure I make sense of a concept of "rights" that doesn't include "responsibilities". My rights are the limiting case of how society must treat me; my responsibilities are the structures of obligation I owe to society. The two necessarily go together. If animals have rights, what are their responsibilities?

If a lion has the right not to be hunted to death, does it also have a responsibility not to eat me? Frankly, I don't trust the lion to keep his half of the deal. Maybe lions are too majestic an example, so let's ask: if rats have the right to be left in peace do they also have the responsibility not to spread disease and wreck our sewerage system?

Again, if the smallpox bacillus, limited now to a few lab-held samples, has the right not to be eradicated completely (as some think it does), should it also have the responsibility to abstain from killing off humans by the billion? I'm being tendentious, I admit. Elephants are large, noble animals; the smallpox bacillus is small and horrid. The question might be where do we draw the line, except that these books argue there shouldn't be a line.

I am not convinced. Let me offer a good rebuttal in the story of US naturalist Timothy Treadwell, who thought he had established cross-species solidarity with certain Alaskan bears.

In Werner Herzog's excellent 2005 documentary about Treadwell's life, *Grizzly Man*, there's a scene where the director listens on headphones, horrified, to a tape of Treadwell's final minutes after the bears had refused solidarity, decided that he looked tasty and eaten him. Herzog turns to Jewel Palovak, the owner of the tape, and a close friend of Treadwell, and says "you should never listen to it [the tape], and you should rather destroy it". ■

Adam Roberts is a writer and critic

Pitch us a movie

Enter our Christmas competition and find out how far your imagination can take you

SCIENCE has been swallowing the film world of late. No sooner did Alfonso Cuarón's 2013 thriller *Gravity* strip space flight back to its heroic basics, than the British Film Institute launched a major national celebration of science fiction, *Sci-Fi: Days of Fear and Wonder*, reminding us of the genre's manifold possibilities and styles. And 2014 ends with the release of two films, that each take a wildly different approach to scientific storytelling.

Interstellar's myth of the near future puts our current climate challenges into cosmic context, while *The Imitation Game* is an intimate and gripping portrait, based in truth, of a remarkable mathematical mind.

Now it's your turn. Whether you want to explore the world through fantastical thought experiments or delve into the day-to-day business of real science, we're offering you the chance to develop your best screenplay idea in the company

No game: Benedict Cumberbatch stars as Alan Turing

of a hand-picked crew of writing professionals.

Send us an "elevator pitch" – describing your film idea in no more than 250 words. Multi-award-winning science fiction writer Kim Stanley Robinson will pick the six best entries we receive by Wednesday 14 January 2015.

Five runners-up will win *Flicker: Your brain on movies*, an insightful new book in which psychologist Jeffrey Zacks describes what happens in your brain when the lights go out in the cinema and the movie begins.

Our first prize is an invitation (by Skype or in person) into *New Scientist's* first ever "writing room", to discuss, develop and hone your winning idea into a film pitch.

Visit newscientist.submittable.com/submit for further details, instructions on how to submit your competition entry, and our full terms and conditions.

We will announce our competition winners on 31 January 2015. ■



SNAP STILL/REX

Y(ou)r q(ua)ntifi(e)d s(el)f

Whether or not your existence is noticed (and 61 per cent of the time it is), whether you detect it or not, you are exquisite. And you are immersed in ... yourself. By **Michael Blumlein**

YOU want to be healthy. You want to know about yourself. You want to be happy. You need to know about yourself. You want to live a long, productive life. It starts and ends with yourself.

How long does it take to get going on an average day? What's your boot-up time? The norm is a bell-shaped curve, much broader than you, personally, would like to see. You'll want to narrow your own curve down. You'll observe what effect this has, right on down the line.

Take your heart, for example. How many times does it beat in a day? Depends on the day. Depends on the heart. But on average, 86,400. That's 8.64×10^4 . For each chamber of your heart (four in all), it's the same number. But for all four chambers combined it's four times as many beats a day. That's 34.4×10^4 (or 3.44×10^5), a substantially higher number. If you narrow your curve, that number might climb as high as 4.2×10^5 . That's a lot of beats. Not too many, mind you. Your heart is built to beat. You'll race out the door. Good job!

Your body is a temple. You have a duty to know how it stands. Your friends who visit the temple, who hang around on the steps – and the lucky ones invited inside – have a right to know the roof won't collapse and the walls won't crumble. They have a vested interest in knowing the building is sound.

How much have you eaten today? How many calories? How many servings? When you stood on the scale this morning, what

did it say? Tip of the week: use the metric system. Kilograms melt away so much faster than pounds. How much faster? More than twice as fast (2.2 times, to be precise). You'll have already knocked off a full kilogram before you've shed even half a pound.

Not trying to lose? Trying to bulk up instead? Same deal: quicker results with the metric system. Even quicker (by a factor of 10^3) if in place of kilograms, you

"Your body is a temple ... the lucky ones invited inside have a right to know the roof won't collapse"

use grams. Good for the forces of change. Good for your head.

How many steps, on average, do you take per day? You know the length of your stride. You know the number of strides between bedroom and kitchen, kitchen and bathroom, bathroom and bed. You know the number of stairs you go up and down each day. You know how many times you shift on your feet while standing at work. How many times you walk down the hall. Your wristband monitors the distance you travel. It measures how many calories you burn. It counts the steps between here and there.

Thirty-six per cent of you are stepping right now. Two out of three will be reading this as you do: reading while exercising is a time-honoured way to maximise your daily throughput score. Sixty-eight per cent of you readers will be riveted by the material.

Eighteen per cent will be nodding off. Be sure to keep your wrist monitor on when your eyes drift closed, whether you're at the desk, on the bus, on the couch or in bed. You'll want to keep track of the distance you log during sleep: during visits to the kitchen, for example, to the bathroom or to check the front door.

If you're a sleepwalker – and a lucky 13 per cent of you are – you'll want to know the duration of your travels, and the average length of your stride. A shuffling walk, you'll note, burns fewer calories than a steady march; a steady march, less than a taut, suspenseful pacing. But all add to the daily count, and when you wake and see what you've unknowingly accomplished, you'll feel as if it's Christmas Day.

No need to dwell on this. You're already counting your steps. You're keeping track of everything you put into your body. You're watching your weight like a hawk. But are you also watching your height?

What shoes are you wearing? Are you tracking their effect on your heart rate, your blood pressure, your mood? How do flats compare to pumps? Shit-kickers to stilettos? Sandals to sneakers?

Seventy-one per cent of you raise your height with footwear between 2.6 and 4.7 centimetres on 76 per cent of days. (Female to male discordance is less than you might think.) Among the artificially elevated, 62 per cent will volunteer an opinion without being prompted. Below 1 cm and

above 7 cm of additional height (or lift), meekness and faux-meekness predominate by a two to one margin.

Height affects your mood, and it affects your world-view. You know this. Eighty-two per cent of you average lifters have experienced a more positive

KYLE THOMPSON/AGENCE VU



outlook, as measured by a shift in the power axis of the Myers-Briggs test. Sixty-eight per cent have noted an increase in appetite, 77 per cent of you have craved to do something you've never done before.

Your altimeter will take care of the numbers; all you have to do is

jot down your mood. Once or twice every hour, which you're doing anyway. You're keeping track of how you feel (what some people call, ambiguously, your "emotional state"). The purpose, of course, is to increase your level of happiness.

Take your bowel movements,

for example. You won't simply be monitoring the number you have in a day. Or a week. You won't merely be measuring their weight, circumference and length. You'll already know to the minute how long you sit on the toilet (if you're a sitter), but what you'll want to know – what you'll

be asking yourself and documenting – is how do you feel? Should you be stretching the time out? Limiting it? Are you straining? What does your manometer say? How much TP do you use? How many sheets per wipe? Per sitting? And what effect, if any, does this have on your so-called emotional state?

And afterwards, when you're cleaning up, do you glance in the mirror? Do you like what you see? Twenty-seven per cent do; 43 per cent don't. Fifty-three per cent will steal another look – in the same mirror, or a different one later. Of these, half will experience a flutter in their pulse. Flutterers live, on average, 168 days longer than non-flutterers. Which are you?

Just breathe

It's your business to be aware, and awareness starts with yourself. Are you breathing? Well of course you're breathing, but are you breathing appropriately for the situation? Are you breathing optimally? During sleep do you slow to a felicitous three breaths per minute? During sex what's your maximum upgrade?

Do you gasp? Is the gasp authentic (A) or manufactured (M)? Females have a high ratio of M gasps: nearly 3:1, when compared to A ones. Males are the reverse but, curiously, the ratio is changing. There's value, it appears, in a simulated, fraudulent gasp: 22 per cent of males attest to this, as compared to a mere 8 per cent a decade ago.

A gasps and M gasps have varying effects on health, but all gasps are salutary. (Survival benefit is clear on the Kaplan-Meier grid.) They may leave you starved for air, but no worries. You'll get your breath back soon. Don't forget to note exactly how soon. If you're still wearing your wrist monitor, this will be measured automatically. If you haven't lied about your weight, you'll know how many calories



NIALL O'LEARY/MILLENNIUM IMAGES, UK

you've consumed. You'll be able to compare this number with the calories used by your friends and acquaintances. You'll know exactly where you stand.

If you're a guy, you'll want to know the volume of your ejaculate. You might be interested to learn you're tossing out, on average, 60 million sperm per millilitre (that's 300 million per teaspoon, or 227 billion per gallon) each time you let fly. If you're an average man, with a 3.5 millilitre ejaculate, that's 210 million of the little guys. You might find this wasteful. Alternatively, you might be pleasantly surprised.

If you're a gal, you'll be monitoring your vaginal blood flow, elasticity and humidity. You'll note how little these correlate with other signifiers of the ideal mate you carry in your head. Experience has taught you that heat in the basement does not automatically translate into heat in the penthouse. Thought is the proverbial wild card, unlike in the male of the species, where the combination of penile vasocongestion and stiffness are 91 per cent effective in rendering thought a lost cause. There's a riddle here (beyond the riddle of the sexes), a little

mathematical brainteaser. Do you see it? Yes. The integral of vaginal blood flow times elasticity divided by gasps per minute defines a Fibonacci sequence. Surprised? Don't be. Is a nautilus surprised by its spirals? A daisy by its petals? A starfish by its arms? You're a creature of our one, beautifully syncopated, beautifully mathematical universe. All living things

"You're not alone in the world ... You're a Boolean entity, every day more Boolean than before"

conform to the same essential living processes. All things, living or not, obey the fundamental principles of existence.

If you exist – whether or not your existence is noticed (61 per cent of the time it is) and whether you yourself detect it or not – you are exquisite. At any given time, a sobering 77 per cent of you will not share this experience. On a scale of 1 to 10, where 10 is absolute, self-conscious, self-absorbed bliss and 1 is self-loathing, self-repulsion and infinite despair, the mean score is 5.3. Some of you will be aghast at this, but most will be cheered, as

you recognise (1) your score is substantially higher and (2) there's ample room for self-improvement.

You will, of course, be wearing oxygen sensors. This goes without saying. The sensors allow you to move – in real-time – from poorly oxygenated areas, such as dance clubs and coal mines, to well-oxygenated ones, such as rainforests and augmented O₂ infusion cubicles, or the reverse, if you choose. Carbon dioxide sensors are also recommended: CO₂ can reach near toxic levels in mere conversation, as other people, your friends or co-workers, for example, surround you and have the audacity to exhale.

Take-home message: you're not alone in the world. Duh. You're a Boolean entity, every day more Boolean than the day before. Worldwide, the interactive overlap is accelerating at the rate of 5.4 per cent. Three out of four people know more about two out of three people than they did 4.2 days ago. Five out of nine know more, but less than they should. Six out of seven are happy on one out of two occasions. Four out of five on one out of three. Nine out of ten wish things were better.

Three out of eight try to make them better. Two out of nine have no idea what's going on.

You'll recognise this latter group. They'll be looking dazed and overcooked. If you have a humane bone in your body (and where else would it be), now is the time to use it. You have no obligation to help, but you'll want to. The fold is growing, you'll say. 8.4×10^6 at last count. There's a movement afoot. No fee to join. Nothing to sign. No leaders.

You'll pause. In 3 to 4 seconds (average 3.3) you'll give the secret sign. Then the secret handshake. You'll want to be careful. You know what can come of extending yourself. You understand the risks of contact of any sort.

You may decide to hold off on the handshake. You may choose to smile instead. Not a full-blown, 43-muscle smile, but not an excessively stingy one either. A 35 to 40 per cent, invitational smile. Consuming a nothing-to-sneeze-at 2.9 joules of energy, and spreading a proportionate amount of caloric encouragement. You'll observe what effect this has, and from here decide what to do next. The odds are 9:5 you'll make the right choice.

You can improve the odds by waiting another 4 minutes before proceeding. This may seem strange to the other party, you standing there without saying or doing anything. Your smile will probably have faded. Your eyes may have taken on a glaze. You may appear distracted or uninterested.

Nothing could be further from the truth.

You're running a risk-benefit analysis.

You're monitoring your 33 most vital signs.

Uninterested? Hardly.

Distracted? Please.

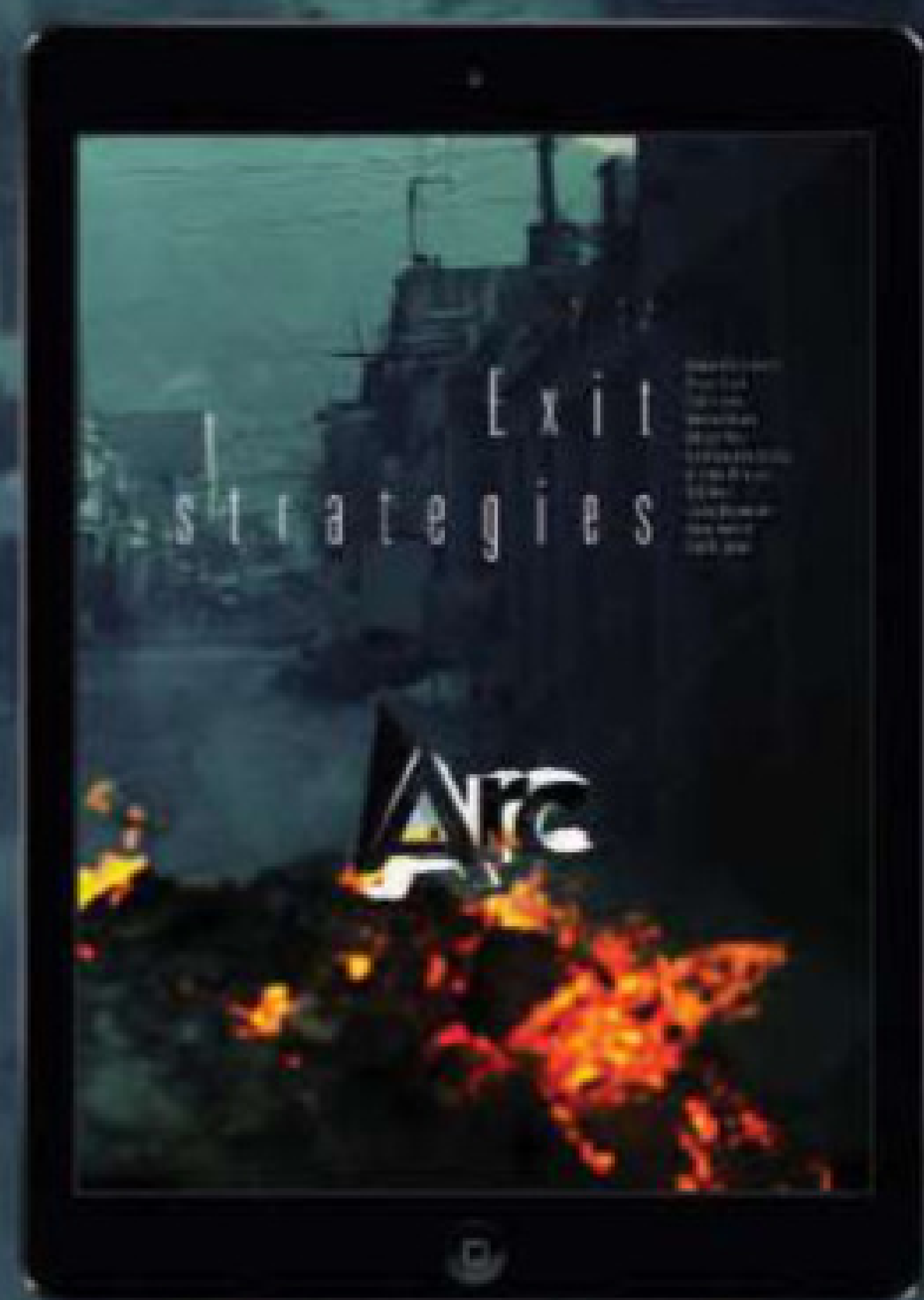
You're immersed. ■

Michael Blumlein teaches and practises medicine at the University of California, San Francisco. This is an abridged version of the work.



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How to Apply

Applications should include a letter describing qualifications and interest in the position. Applicants should include a description of relevant experience and accomplishments, a curriculum vitae, and the names and addresses of four references. Review of applications will begin Jan. 15, 2015, but applications will be accepted until the position is filled.

- **Email Applications To:** jsgchair@jsg.utexas.edu
- **Or Mail To:** Search Committee Chair, Office of the Dean
Jackson School of Geosciences
The University of Texas at Austin
2305 Speedway, Stop C1160
Austin, TX 78712-1692

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GROWING IANR

Faculty Positions

Institute of Agriculture and Natural Resources The University of Nebraska-Lincoln

The Institute of Agriculture and Natural Resources (IANR) at the University of Nebraska-Lincoln (UNL) is committed to world-class excellence in applications of agricultural and life sciences towards a sustained high quality of life for the citizens of Nebraska, and for a quickly growing global population. Early in 2013, reflecting this commitment, IANR launched an initiative to hire new tenure-track faculty members in strategic impact areas of Science Literacy; Stress Biology of Plants, Animals, and Agroecosystems; Healthy Humans; Healthy Systems for Agricultural Production and Natural Resources; and Computational Sciences. This Phase 1 effort was very successful, resulting in the recruitment and hiring of 35 highly skilled tenure-line faculty members (with two searches still active).

We are pleased to announce Phase 2 of this effort with recruitment for an anticipated 30+ additional tenure-line faculty positions. The focus for Phase 2 will be to strengthen the six strategic impact areas in Phase 1, with an additional focus area – Drivers of Economic Vitality for Nebraska.

We invite you to view brief explanations of the positions currently being released and those to be released soon at <http://ianr.unl.edu> to explore whether your skills and experience make you a good fit for our team.

The positions will be advertised and posted beginning December 1, 2014. We invite you to visit the UNL employment web site at <http://employment.unl.edu> to learn which positions are posted.

The University of Nebraska is committed to a pluralistic campus community through affirmative action, equal opportunity, work-life balance, and dual careers.



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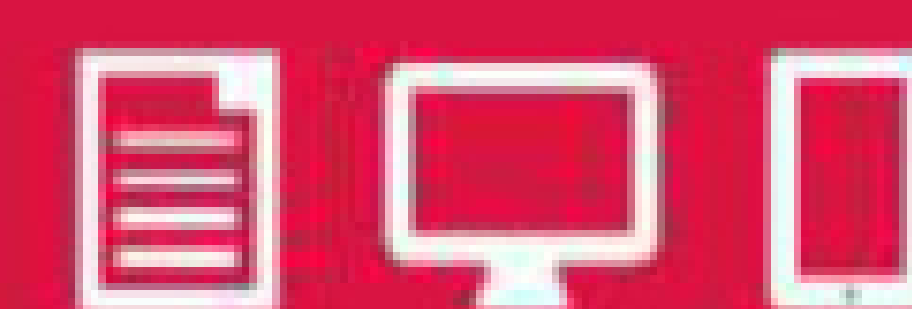
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Research Scientist for Next-Generation Sequencing and Bioinformatics

The Wadsworth Center (Albany, NY) is seeking an outstanding scientist to join its Public Health Genomics Center. The successful applicant will be responsible for the development and implementation of next-generation sequencing and associated bioinformatics analyses in the research and public health programs of the Center. He or she will collaborate with research scientists to develop cutting-edge approaches for applications such as, pathogen identification, outbreak tracking, mapping drug-resistance determinants and novel genetic testing. In addition, there will be opportunities to participate in the various educational activities offered by the Wadsworth Center.

The Wadsworth Center (www.wadsworth.org) is the country's most comprehensive state public health laboratory with a staff of about 750. The Center provides a dynamic research environment focused on infectious, genetic and environmental diseases and their impact on human health. Through its initiative for Public Health Genomics, the Center will bring NGS and other advanced molecular technologies to public health testing, diagnosis, and research, further develop these technologies to address new and emerging challenges, and become a regional center of excellence for NGS in the area of public health genomics.

Ph.D. degree or equivalent and one to two years of relevant postdoctoral research preferred. Experience with various approaches for sample preparation for sequencing of microbial specimens and applications of different sequencing strategies is desired. Applicants should submit a cover letter, curriculum vitae, and contact information for at least three references to wcphgc@health.ny.gov, referencing posting RS3/4/12137. Applications will be accepted until the position is filled and reviewed as they are received. AA/EOE.

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2015 The Louisa Gross Horwitz Prize for Biology or Biochemistry

The Louisa Gross Horwitz Prize was established under the will of the late S. Gross Horwitz through a bequest to Columbia University and is named to honor the donor's mother. Louisa Gross Horwitz was the daughter of Dr. Samuel David Gross (1805-1889), a prominent surgeon of Philadelphia and author of the outstanding *Systems of Surgery* who served as President of the American Medical Association.

Each year since its inception in 1967, the Louisa Gross Horwitz Prize has been awarded by Columbia University for outstanding basic research in the fields of biology or biochemistry. The purpose of this award is to honor a scientific investigator or group of investigators whose contributions to knowledge in either of these fields are deemed worthy of special recognition.

The Prize consists of an honorarium and a citation which are awarded at a special presentation event. Unless otherwise recommended by the Prize Committee, the Prize is awarded annually. Dr. James P. Allison, University of Texas MD Anderson Cancer Center was the 2014 awardee.

Qualifications for the award

The Prize Committee recognizes no geographical limitations. The Prize may be awarded to an individual or a group. When the Prize is awarded to a group, the honorarium will be divided among the recipients, but each member will receive a citation. Preference will be given to work done in the recent past.

Nominations must be submitted electronically at: <http://www.cumc.columbia.edu/research/horwitz-prize>

All communications and materials must be written in the English language.

Deadline date: January 30, 2015

Re-nomination(s) are by invitation only. Self-nominations are not permitted.

Nominations should include:

- 1) A summary, no more than 500 words long, of the research on which this nomination is based.
- 2) A summary, no more than 500 words long, of the significance of this research in the fields of biology or biochemistry.
- 3) A brief biographical sketch of the nominee, including positions held and awards received by the nominee.
- 4) A listing of up to ten of the nominee's most significant publications relating to the research noted under item 1.
- 5) A copy of the nominee's curriculum vitae.

Software Developer Upstream Oil and Gas - Houston TX, US

Tessella is a global analytics, software services and IT consulting company that works with some of the world's leading organizations in energy, pharmaceuticals, consumer goods and the public sector to solve complex, real-world problems. We are currently looking to recruit a software developer, preferably with exposure to the Oil & Gas industry.

The Role

A career at Tessella offers a varied, challenging and rewarding opportunity to combine science, software engineering and data analytics. Projects may include:

- Working closely with our customers to help identify and define their requirements.
- Helping design and develop tailor made software solutions. Getting involved in all stages of the software development lifecycle.
- Helping our customers to better understand their data to improve their processes.

Requirements

- Bachelors / Masters degree in engineering or science (ideally in geophysics, geotechnical engineering, petroleum engineering or similar). A PhD is a plus.
- Experience of technical / scientific software development in either C#, C++, .NET or Java.
- Excellent communication skills and the ability to explain complex technical solutions to customers and colleagues from all backgrounds.
- It would be an advantage to have experience of oil/gas exploration, drilling, geophysical or seismic industry and/or relevant commercial software tools. This experience could have been gained through an internship or academic studies, if not professionally.

What We Offer

In addition to a competitive salary and benefits, we offer an annual training allowance of 150 hours to each employee, which can be used to learn technical or soft skills or earn recognised professional qualifications.

As your career progresses, we offer good future prospects. A technical career path is open to staff who wish to focus on technology and become technical architects of our software. Alternatively a project management / leadership route is available for staff who wish to develop their organizational and people management skills.

About Tessella

Tessella is a global analytics, software services and IT consulting company that works with some of the world's leading organizations in energy, pharmaceuticals, consumer goods and the public sector. In the oil and gas sector, Tessella helps the science and engineering teams of leading energy organizations to meet critical business goals, from improving safety and protecting the environment to enhancing decision support and knowledge sharing. We are also experts in the fields of big data and analytics, and our energy clients rely on us to help them draw meaningful conclusions from the flood of oilfield data.

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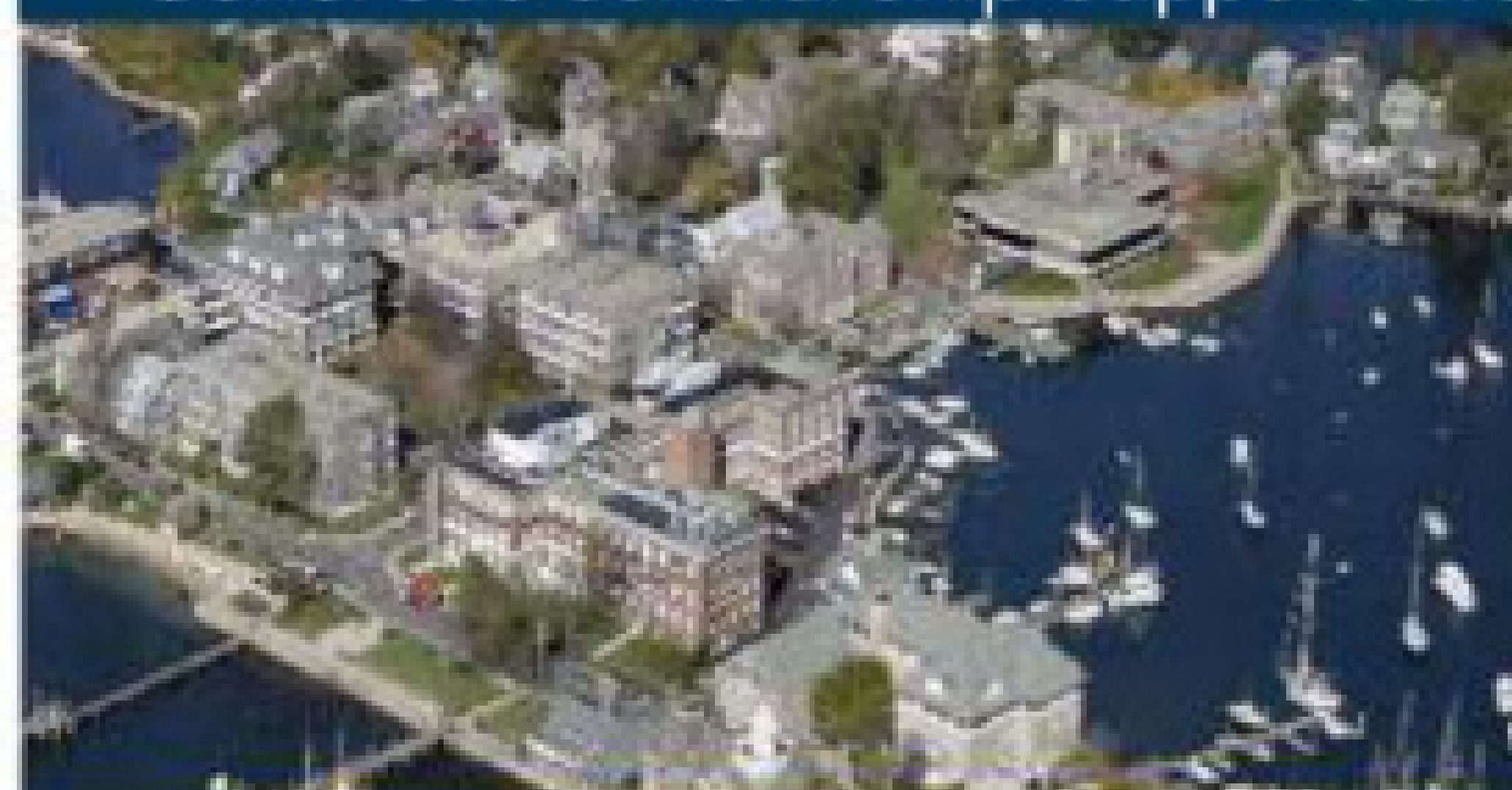
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Institute for
Quantum
Computing

Faculty Positions

Applications are invited for 1 or more tenured/tenure-track faculty positions at the Institute for Quantum Computing (IQC) and any department in the Faculties of Engineering, Mathematics and Science. The IQC is a collaborative research institute focused on realizing quantum technologies including sensors, actuators, quantum communication, and information processors. Membership in IQC is renewable, with an initial appointment of 5 years, and comes with research space, a teaching reduction of one course and a stipend. Only those candidates whose research program directly connects with the goals and ongoing research in IQC will be considered. Information about research at IQC can be found at <http://uwaterloo.ca/iqc/research>

A PhD and significant evidence of excellence in research in quantum information science and technology and the potential for effective teaching are required. Responsibilities include the supervision of graduate students, as well as teaching at the undergraduate and graduate levels. Based on qualifications, rank hired at and Faculty/Dept. cross-appointed to, salary range of \$75,000 to \$185,000 will be considered. Negotiations beyond this salary range will be considered for exceptionally qualified candidates. Effective date of appointment is negotiable. The search is open to all areas of quantum information and all faculty levels. The search committee will consider all creative and energetic candidates in any area of research focused on advancing quantum information.

The University of Waterloo is host to the Institute for Quantum Computing. At present, IQC has a complement of 22 faculty members (growing to 33) from the Faculties of Engineering, Mathematics and Science. Interested individuals should upload their application via the faculty application form at: <http://uwaterloo.ca/iqc/positions>.

The application review process will begin on December 1, 2014 and continue until March 31, 2015.

The University of Waterloo respects, appreciates and encourages diversity. We welcome applications from all qualified individuals including women, members of visible minorities, Aboriginal peoples and persons with disabilities. All qualified candidates are encouraged to apply; however, Canadian citizens and permanent residents will be given priority.

Three reasons to apply: <https://uwaterloo.ca/watport/why-waterloo>.



Working with clients and partners, the National Research Council Canada provides strategic research, innovation support, scientific and technical services to develop and deploy solutions to meet Canada's current and future industrial and societal needs. Guided by our core values of impact, accountability, leadership, integrity and collaboration, NRC is a dynamic and vibrant organization that, in its ongoing evolution, is seeking multiple research positions with our Human Health Therapeutics (HHT) Portfolio.

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We are looking for motivated Team Leaders in the following areas:

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Competition #122-14-0265 Ottawa, Ontario English

Team Leader - Biophysical Assays and Characterization of Biologics

Competition #122-14-0289 Montréal, Québec Bilingual BBB/BBB

Team Leader - Animal Cell Scale-up

Competition #122-14-0360 Montréal, Québec Bilingual BBB/BBB

Section Head - Process Development and Scale-up

Competition #122-14-0362 Montréal, Québec Bilingual BBB/BBB

To apply for any of these roles go to

<http://www.nrc-cnrc.gc.ca/eng/careers/competitions/index.html>



SNARKS: what kind of particle would they be? Confronted with a piece of fruitlooperly defining “quarky behaviour” as emitting “small, negative message clouds”, our sense of lexical symmetry demanded a particle of that name (8 November).

We had in mind “snark”, in the sense of a snippy comment. Magnus Peterson was just one of the readers who reminded us that Lewis Carroll had anticipated us in his poem *The Hunting of the Snark*: “To deal properly with quantum fruitlooperly, you need a boojum. Because, encountering it, purveyors of management gonads and all that ilk will softly and suddenly vanish away.”

John Davies points us to Vonda McIntyre’s novelised version of the film *Star Trek II: The Wrath of Khan*, which mentions sub-subatomic particles called “snarks” and “boojums”. A novelised film could possibly

be a metafiction. It’s just as well we didn’t make this up, because that’d be a meta-metafiction.

WHAT are your views on the Sea Fish (Conservation) Act 1992? The UK Law Commission proposes repealing section 10 of this Act, on the grounds that it only required ministers to make a report on its functioning by the summer of 1997 – which they did.

This is part of a tidying-up exercise that proposes to delete from the statute book parts of 49 Acts of Parliament, including the SF(C)A and the Statute of Marlborough of 1267, and the whole of 56 more. Some of these Acts have, over the years, had every section except that defining their title repealed. Feedback sees the point of removing these. But why bother with the report-making provision? Surely, like apparently non-coding DNA, it’s a harmless part of the history of the code?

Heaven forfend that the Law Commission should create a piece

of “red tape” for the sole purpose of being able to claim that the maximum amount of red tape has been ruthlessly cut.

SPEAKING of which, Feedback has mislaid our sample of actual, physical red tape. Fortunately, *New Scientist*’s London office is a short walk from a purveyor of legal supplies that for £96.96 will sell us 500 metres of the stuff – in fact magenta – which is used to tie up legal document bundles. We are minded to buy some for ministers to cut, to distract them from repealing useful regulations.

SOME knotty tape that could usefully be cut reaches a colleague from Arun District Council, a local authority in the UK. The registration process for voting has changed here. “If you wish your name to be removed from the open register,” Nigel Lynn, registration officer, warns: “then please complete the box overleaf”.

Chuffed about the possibility of preventing people from getting identity details, the colleague turned over the page and read the box to sign: “I wish my name to be added to the open register”. We reckon this gives signers an evens chance of achieving the opposite of what they want.

PRECISION being a virtue: while thanking Robert Cailliau for sending a film on information-science pioneer Paul Otlet, we called Cailliau “co-inventor of the World Wide Web” (15 November). He prefers to be described as “web pioneer”.

ARCHITECTURE isn’t a field of expertise that Feedback claims. But we have a question for those who are qualified. The other week, leaving London from St Pancras station, we glanced at the Francis Crick Institute, an interdisciplinary medical research facility being built next to it. When first proposed, it aroused some anxiety because it will contain 700 square metres of laboratories rated at containment level “3 or higher” – though the Institute’s

website reassures us that it will not handle Containment Level 4 bugs.

What we want to ask is: given this, was it really necessary to make the defining feature of the roofline, as seen from the railway – and thus the first thing some visitors from Brussels and Paris will see on arrival – a busy array of vents and chimneys?

THIS time last year, Jon Hinwood wrote of “pausing in decorating my Christmas tree for a cuppa and a read of *New Scientist* – and finding that I had set up a simple demonstration of the master-slave oscillator system described in the article ‘Crashing market, hidden dragon?’ (23 November 2013, p 8)”. He described chaotic motion of the baubles and its resemblance to the financial-market excursions discussed in the article. Please take care what you accidentally model, should you be arranging seasonal ornaments of any persuasion.



FINALLY, it remains – in this, *New Scientist*’s issue 3000 – for Feedback to thank you for the 3362 other messages we have received in the past 12 months. Almost all are very interesting, though sadly we have had neither space to mention nor time to thank you individually for all of them. Season’s greetings to you all!

You can send stories to Feedback by email at feedback@newscientist.com. Please include your home address. This week’s and past Feedbacks can be seen on our website.

Cloud-backup service Carbonite informs Barny Shergold that if he takes no further action, his file will be deleted in 49,698 days. Do they know something about the year 2150 that we don’t?

Paying attention?

Oops, we forgot to tell you there would be an end-of-year exam. Compiled by **James Harkin**

For this year's quiz, *New Scientist* has teamed up with the QI Elves, the researchers behind the brilliant BBC panel show *QI* and its many spin-offs (see page 40). The Elves read *New Scientist* every week, plucking out the juiciest and most surprising facts to use in their TV shows, radio shows, podcasts and books. Here is a quiz based on their 10 favourite things they learned from *New Scientist* this year.

- 1. Which of the following is untrue of Neanderthals?
a) They looked after disabled individuals
b) They hunted and ate pigeons
c) They could hear sounds that no known animal can make
- 2. How does your brain compare with that of a *Homo sapiens* living 10,000 years ago?
a) 5 per cent bigger
b) 15 per cent smaller
c) 50 per cent wrinklier

- 3. Which of the following describes raindrops on the sun?
a) They are the size of Ireland
b) They are the shape of doughnuts
c) They smell of geraniums
- 4. Cars on motorways are noisy, but where does that noise mostly come from?
a) The engine
b) The wheels
c) The air rushing past
- 5. What were the dominant animals on the Hawaiian islands (though not Hawaii itself) before humans arrived?
a) Giant ducks
b) Flying snakes
c) Carnivorous slugs
- 6. Which of the following is of particular importance to car manufacturers?
a) A pleasant-sounding dashboard
b) Windscreens containing the golden ratio
c) Cup holders manufactured in the country of sale



- 7. What is the only computer to win a quiz show doing these days?
a) It has its own chat show on the American Heroes Channel
b) It predicts the path of hurricanes in the Caribbean
c) It is saving lives in the medical sector
- 8. When is the best time for hand-eye coordination?
a) 6am
b) 8pm
c) 1am

- 10. Which of the following is true of Agatha Christie?
a) She had an imaginary friend into her 70s
b) She distilled her own whisky
c) She worked as an astronomer's assistant
- 9. Approximately how much does it cost to sequence a human genome?
a) \$25
b) \$1000
c) \$2.5 million



The latest QI book is *1,411 QI Facts to Knock you Sideways* by John Lloyd, John Mitchinson and James Harkin (Faber & Faber)

ANSWERS

1 c Our understanding of Neanderthals is changing all the time. We now know that they looked after their old and disabled and that they hunted and ate pigeons. There's no evidence that they heard sounds that no known animal can make: that is a skill of the greater wax moth, *Galleria mellonella*.

2 b Humans 10,000 years ago had brains that were 15 per cent larger than ours. Nobody knows if that change means we are less intelligent, or if it's simply that our brains have become more efficient.

3 a It does rain on the sun, but the rain comes in the form of "droplets" of plasma the size of Ireland, falling from the height of 63,000 kilometres at 200,000 kilometres per hour.

4 b Contrary to popular belief, at 100 km/hour, 90 per cent of the noise a car makes comes from the interaction with the road, not from the engine.

5 a The dominant animals on the islands before humans arrived were giant flightless ducks called moa-nalos. They thrived for 3 million years before being hunted to extinction.

6 a One in four people tap the dashboard when inspecting a new car. Manufacturers know this, so deliberately make the sound pleasing.

7 c After winning \$1 million on *Jeopardy!* in 2011, the computer Watson has been working to assess humans' genetic risk of cardiac arrest as well as recommending treatment for lung cancer.

8 b The best time of the day for hand-eye coordination is 8pm and the best time to do anything involving thinking is between 4pm and 10pm.

The absolute worst time for the brain to try doing stuff is, unsurprisingly, between midnight and 6am.

9 b In 2000 it cost \$3 billion to sequence a human genome. In 2014 the price fell below \$1000 for the first time.

10 a Agatha Christie still spoke to her imaginary friend into her 70s. Studies suggest that having imaginary friends is perfectly normal and can help children cope with real-life difficulties.

DREAMS CANNOT BE RUSHED.



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